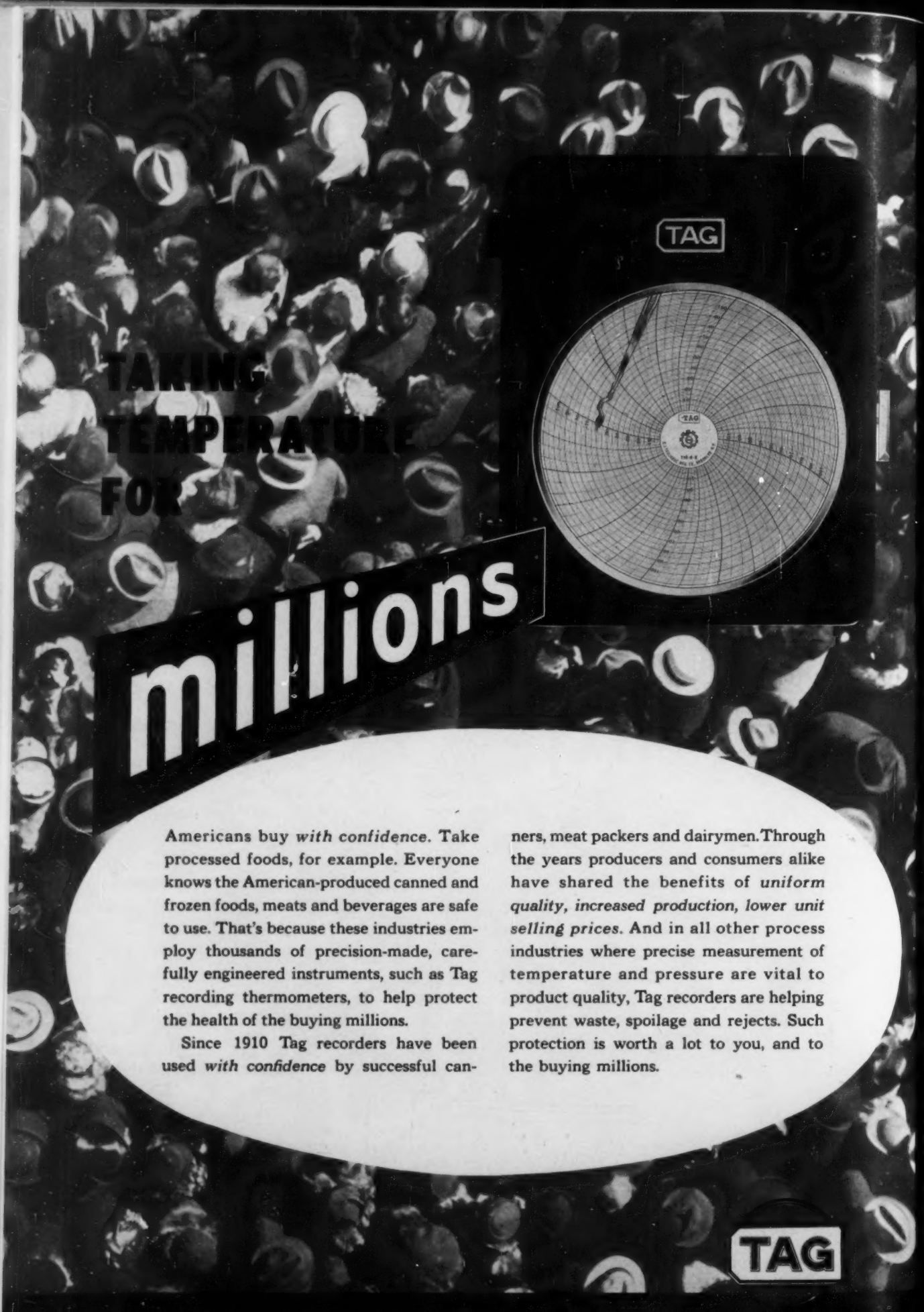
Instruments

IE MAGAZINE of MEASUREMENT and CONTROL

Vol. 21 MARCH 1948 No. 3

luding the JOURNAL of the Instrument Society of America



Americans buy *with confidence*. Take processed foods, for example. Everyone knows the American-produced canned and frozen foods, meats and beverages are safe to use. That's because these industries employ thousands of precision-made, carefully engineered instruments, such as Tag recording thermometers, to help protect the health of the buying millions.

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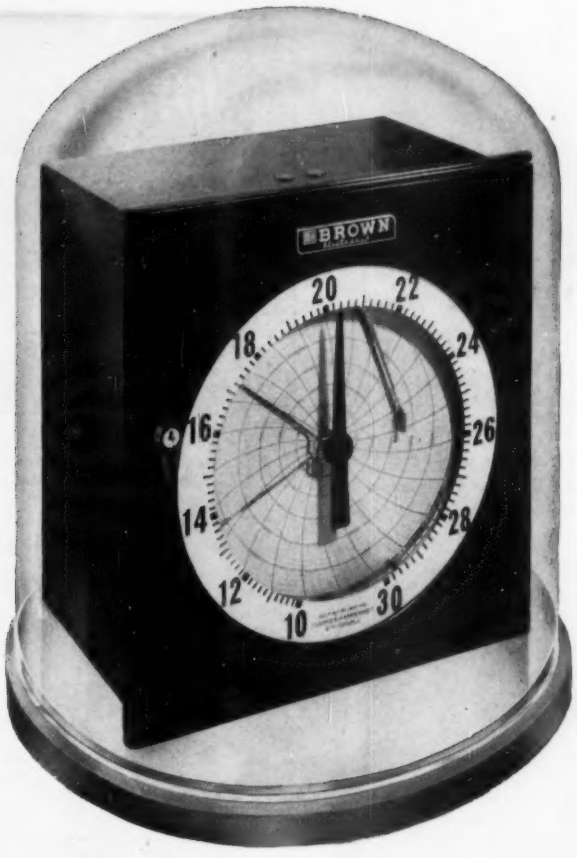

How to cut down instrument maintenance

You could cut down maintenance if you kept your instruments under bell jars. Dirt, dust and corrosive atmosphere would be sealed out. Dirty control contacts would be eliminated.

But don't requisition bell jars yet. Essentially, we've built better than bell jars right inside the Brown *ElectroniK* Potentiometer. Practically all the moving parts have been put into electronic vacuum tubes. The important control contacts are mercury switches forever sealed in glass—permanently protected against atmospheric conditions. The few moving parts are rugged and oversized, and all protected by a dust and moisture-resistant instrument case.

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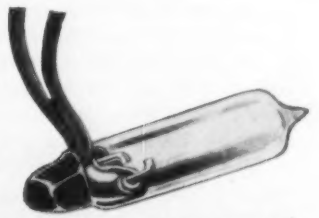

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Instruments THE MAGAZINE OF *Measurement and Control*

Vol. 21 **March 1948** No. 3

TWENTIETH ANNIVERSARY FEATURE

A "Historical Museum *on* Paper" *of* American Instruments *in* Science *and* Industry

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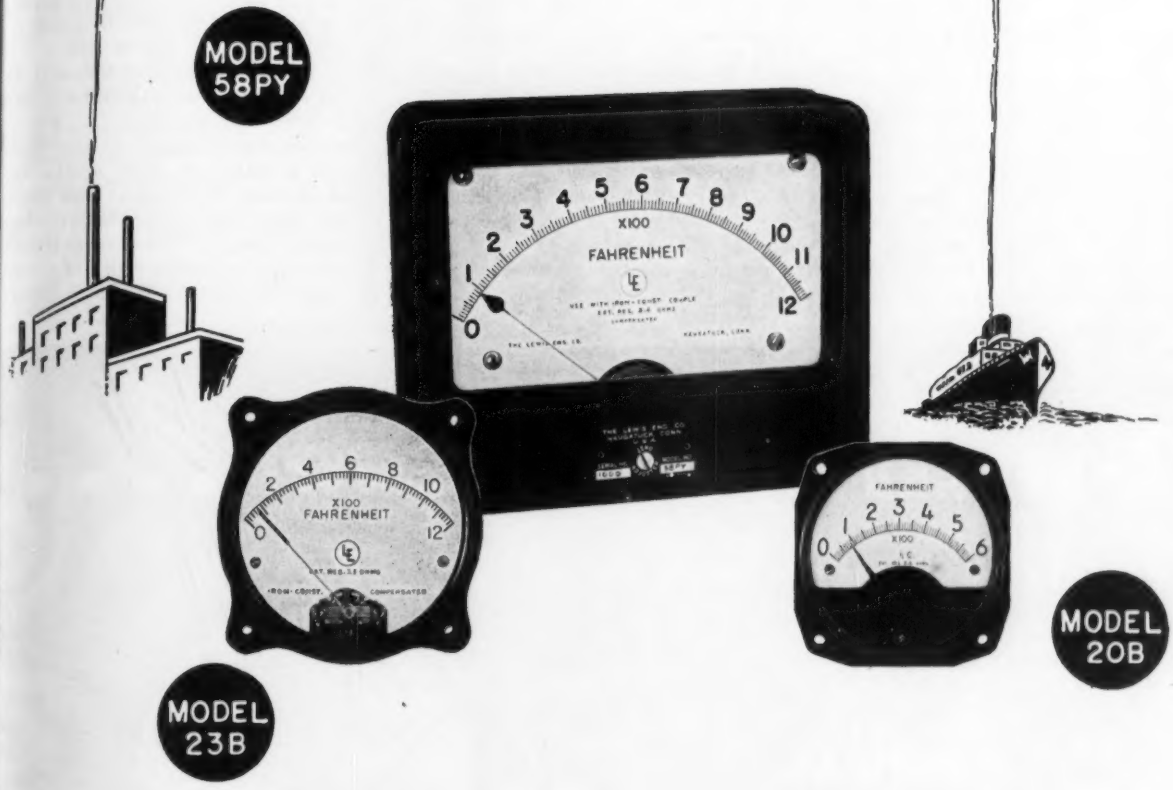
Industrial and Marine



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INSTRUMENTS ON THE MARCH

Conference on Electron Tubes for Instrumentation

NEW YORK CITY.—An important innovation in American Institute of Electrical Engineers meetings is being inaugurated in 1948 by several of the national technical committees of the Institute. These are to be known as AIEE conferences. As presently conceived, the sponsoring technical committee will arrange the complete technical program.

The programs are planned to be technical, featuring ample opportunity for informal discussion by all attending. AIEE members and nonmembers will be solicited to attend and take part. Several of these conferences are planned for 1948.

The Subcommittee on Electronic Instruments is rounding out program plans for the AIEE Conference on Electron Tubes for Instrumentation and industrial use to be held at the Benjamin Franklin Hotel, Philadelphia, Pa., March 29-30, 1948. The tentative program will feature technical sessions both days, including one Monday evening. This shortens the conference to two days rather than three as previously announced. Some of the principal features to be presented:

1. Statement of objectives, including outline of need for improved tubes, by representatives of instrument makers.
2. Results of survey conducted by subcommittee to determine the demand for electron tubes for instrumentation and special purposes, and their requirements.
3. Outline of programs of electron tube development and improvement project by special user groups in other fields.
4. A discussion of instrument tube possibilities by representatives of tube manufacturers, which will include manufacturing limitations and economic considerations.
5. Open discussion of proposed special tubes by functional types.

A dinner will be held Monday evening. The highlight of the after-dinner program will be a talk on a pertinent subject by a speaker prominent in the electrical field.

Free Courses for Inspectors

LANSDALE, PENNA.—The Hunter Pressed Steel Co. will, on April 16, inaugurate a weekly series of free two-day training courses for inspection personnel (enrolled by their managements) on "Modern Parts-inspection Techniques and Simplified Statistical Methods of Analysis of Data."

Although the course has been planned for inspectors, it is believed that purchasing agents and product designers will also want to take it. Both groups are welcome.

The course (Tuesday and Wednesday of each week), will involve seven lectures by top specialists in the field, one forum-type discussion, a complete plant tour to demonstrate Hunter's methods of "taking its own medicine," and a full afternoon of actual testing and calculating practice in using the principles learned. The course will be given in Lansdale, and the only expenses involved will be living and traveling costs.

An interesting facet of the course will be actual work with several new types of testing machines and instruments which have just recently been developed for the exact measurement of important characteristics of the notoriously hard-to-measure coil springs.

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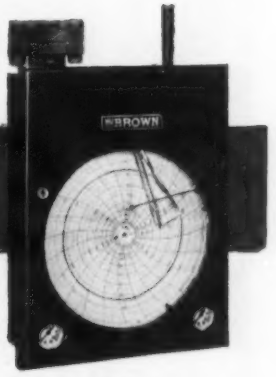
1—Calibration Error					
Average Upscale	0.15%	0.48%	0.41%	0.22%	0.15%
Average Downscale	0.16%	0.58%	0.49%	0.19%	0.50%
Maximum	0.50%	1.10%	1.43%	0.40%	0.80%
Minimum	0.00%	0.00%	0.00%	0.00%	0.00%
2—Readability	A	B	B	B	B
3—Sensitivity	0.10%	0.12%	0.12%	0.12%	0.10%
4—Dead Zone	0.23%	0.25%	0.23%	0.23%	0.70%
5—Response Speed	22 secs		42 secs	32 secs	37 secs
Overload Seal	B	C	B	B	A
Adjustments					
Zero	A	C	B	C	B
Pulsation	A	C	C	C	B

A = Superior B = Satisfactory C = Inferior



Consider the results of this comparative *performance* test conducted Brown engineers.

The test sought the answer to the all-important questions: In the final alysis, what is the flow meter's ultimate installed performance? How sy is the meter to operate and maintain at top performance?

Every effort was made to be unbiased. Regular production models were ed, from the Brown plant as well as from competitors. Each meter was refully adjusted for best performance. On competitive meters, if the s received" calibration was poor, the instrument was recalibrated to tain minimum error.

The figures speak for us. Brown more consistently ranks "tops" in rformance features. Let us prove it in your plant under your operating nditions.

Performance counts!

descriptive booklet will gladly be sent to you. Ask for Catalog No. 2221.

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NOTES

All percentages are based on per cent of full scale differential pressure.

1. **Calibration Error:** Difference between instrument readings and an accurate standard water column.
2. **Readability:** A function of length of arc for full scale pen travel and of number and fineness of chart graduations.
3. **Sensitivity:** Minimum change in the differential pressure required to cause motion of pen.
4. **Dead Zone:** Zone in which differential pressure can be varied, from a set point, both up and downscale, without causing pen motion.
5. **Response Speed:** Time required for instrument to record an instantaneous 100% change in differential pressure.

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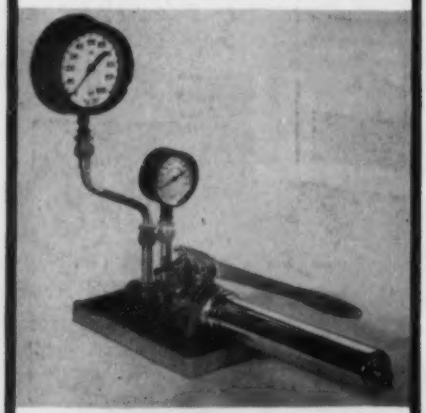
WILL SERVE 3 WAYS

10,000 psi—no leakage or seepage

1 PORTABLE PRESSURE TESTING
Weight, filled with oil, 8½ lbs.



2 BENCH WORK WITH TEST GAGE
mounted on aluminum drip pan

3 DEAD WEIGHT TESTING
shown with dead weight attachment mounted on unit.
Write for Bulletin

MANSFIELD & GREEN
1051 Power Avenue CLEVELAND 14, O.

Hunter and others expect such instruments soon to come into widespread use, and feel that understanding of their handling and importance is vital at this time.

Ten men can be enrolled at a time, and it is urged that all men from a given company come in a group. Already the first few weeks are "sold out" to the inspection departments of larger Hunter customer organizations. The courses will be continued until all qualified enrollees have been processed —even if it takes five years.

In charge is Philip C. Clarke, Asst. Gen. Mgr., Hunter Pressed Steel Co., Lansdale, Penna.

New Photoelastic Resin To Aid Stress Study

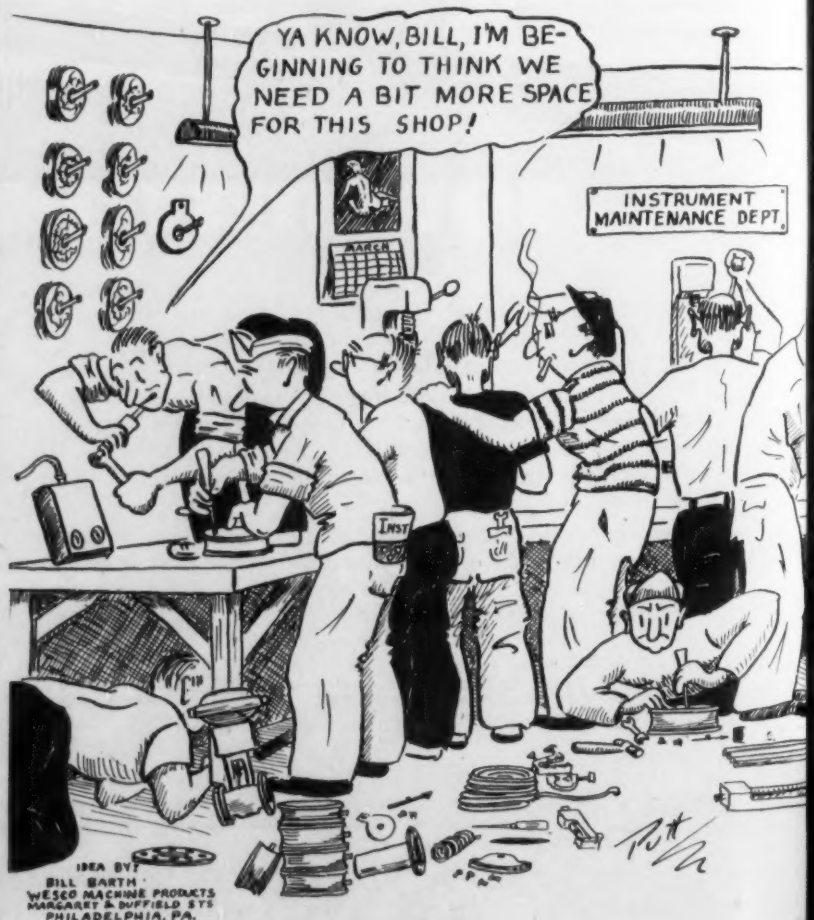
PITTSBURGH, PA.—A special process developed by H. F. Minter and M. M. Leven of the Westinghouse Research laboratories now permits large sections of a photoelastic resin of the Fosterite family to be cast for three-dimensional studies of "frozen stresses." It is believed that sizes and shapes suitable for any kind of three-dimensional study can be produced. One piece measures 6" in diameter and feet long. In the past, plastic models made of ordinary photoelastic resins have been limited to pieces 1⅛" thick. The new resin is 35% more optically sensitive for "frozen stress" measurements than the standard material. It does not fade in usefulness with time and can be used for precision studies a month after machining. It is still in the experimental stage and is not yet available commercially.

SESA to Meet in Pittsburgh

CAMBRIDGE, MASS.—The Annual Meeting of the Society for Experimental Stress Analysis will be held at the Roosevelt Hotel, Pittsburgh, Penna., on May 27, 28, 29, 1948. Inquiries should be addressed to the society for Experimental Stress Analysis, P. O. Box 168, Cambridge 39, Massachusetts.

WHEN A FELLER NEEDS CONTROL

By Phil Putnam


YA KNOW, BILL, I'M BEGINNING TO THINK WE NEED A BIT MORE SPACE FOR THIS SHOP!
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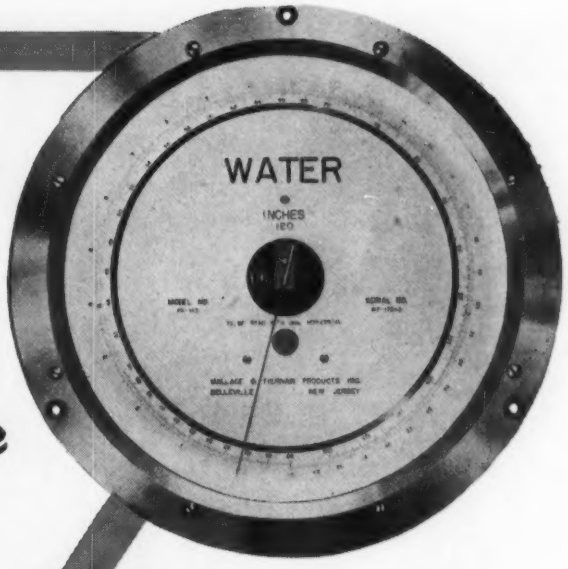

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The W&T Precision Dial Manometer is a universal type instrument for both pressure and vacuum measurement. It is compact and extremely sensitive with a high degree of readability. These features, together with fine accuracy, have proved of value in such applications as gas turbine testing, balanced diaphragm dynamometer and torque stand installations, pressure instrument checking and calibration and aircraft and automotive power plant research.

Here are some design characteristics:

Range	up to 200 inches of mercury gauge or differential
Accuracy	1 part in 1000
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Scale Length	45 inches (custom calibrated—linear or expanded zero)
Dial Diameter	8½″
Case	pressure tight, metal, for flush mounting

Write for free Technical Publication on the Precision Dial Manometer.

A-67

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Cost Picture Brightens For Tubing Users

The present need for cutting production costs is resulting in a search by industrial executives to eliminate as many unnecessary plant operations as possible. In order to fulfill this need for its own customers, the Precision Tube Company of Philadelphia has acquired new facilities which enable it to relieve the manufacturer of one or more secondary operations. Consequently, it is able to apply skilled personnel and thirty years of experience to fabricating non-ferrous precision tubing right in its own plant. As a result, Precision Tubing now arrives at the user's plant as a finished part, in whatever shape he specifies, ready for immediate application.

Forming, cutting, flaring, spinning, soldering, and brazing are but a few of the many services the Precision Tube Company has added. To the customer this means secondary operations are performed at a cost lower than he, himself, can usually provide. Experienced personnel now perform the entire operation. When this is considered in addition to the great volume going through the Precision Tube plant, it can readily be seen that the customer enjoys the benefits of receiving a *more finished* product in *less* time.

Even with this increased service, the company continues to provide a product which has been the keynote to quality for many years . . . lives up to its slogan: "When precision counts . . . count on Precision".

The specifications on accuracy, consistent mechanical properties, and good finish are embodied in all Precision Products to the highest degree. Each is the result of years of experience in careful production control, laboratory studies, and a general tube-making know-how cultivated by the exacting requirements of its most critical customers. The result has been a decrease in inspection for the user and an ease of installation which have imbued him with unwavering confidence in products containing Precision Tubing.

For your new applications, the engineering department of the Precision Tube Company will be glad to review your needs and make recommendations. Whatever your requirements — copper, brass, nickel, monel, aluminum alloys, phosphor-bronze, cupro-nickel, nickel silver, or other non-ferrous alloys— your inquiries are cordially invited.

Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

History in the Making

ONE of the most frequent comments on our January and February issues—in which the "Historical Museum of American Instruments" was featured — runs somewhat as follows:

I was fascinated by those nineteenth-century developments and by all those in your "Third Gallery"—to the end of World War I—then the instruments in your "Fourth Gallery" began to look familiar; and many of those in your "Fifth Gallery" which ends with the year 1939 are old acquaintances.

A frequent comment on the two "galleries" in this issue will be that most of the instruments brought out in 1940-1943 are being used today. And—no doubt—a comment on the 1944 and 1945 "galleries" in our next issue will be that those pages look like our New Instruments Department.

It is for this reason that our "Historical Museum" will conclude with 1945. The numerous descriptions of post-war instruments submitted for inclusion in our Twentieth Anniversary Historical Feature would not merely look like a new-products department: if printed in the same style as the other "galleries," they would BE a new-instruments department—a redundant department because these devices WERE reported when they were brought out since January 1946.

By this time, dear reader, the thought has occurred to you that our REGULAR New Instruments Department is a regular report of history in the making. It is that, beyond all doubt—and it has served that purpose for many years. But it is more that only that: it serves many purposes much more practical than that of a chronicle of current history. It is a tool which, intelligently applied by thousands of Instrument Men from "mechanics" to "presidents," advances our American industrial civilization by leaps and bounds. But this tool is not an automatic instrument: it must be used consistently in order to benefit our civilization. Casually glancing through it is not using it. A good way to use it is to read it attentively, with a pen or pencil in one's hand to jot down ideas or to jot down numbers to enter on the request card. Then, when the additional information comes from the instrument-makers, this information should likewise be studied. Finally, if the facts dictate a course of action, such action should be taken. Thus is history made!

While on this SAME subject, we invite attention to the "editorial" below. To the questions asked by Mr. Tobi in the title (his own title), and in his final paragraph, one answer is that Instrument Men who lack a formal engineering education can make themselves more useful than an outside Instrument Engineer by keeping abreast of all new developments—by consistently using such tools as the New Instruments Department.

—MFB

LETTER TO THE EDITOR

Are the Instrument Engineers Getting Ahead of the Instrument Men?

To the Editor of *Instruments:*

Instrument engineers may be broadly classified into four groups: (1) design and research, (2) application, (3) sales, and (4) maintenance.

Design and research engineers are highly specialized. For example, to design electrical equipment, it is necessary to know the fundamental components of networks and, if non-linear impedances are encountered, the mathematical analysis becomes very difficult. These engineers have little time in which to become familiar with equipment in other fields.

An application engineer in the process industries selects equipment that will give the best control at the least cost; he is able to make flow and other calculations affecting instrument performance and operation; he is acquainted with the limitations of the various classes and types of instruments—but without having to know the details of instrument design and construction.

The sales engineer's knowledge is similar to that of the application engineer, but more specialized. Since he works with only one make of equipment, he knows its operation and construction in addition to being able to specify the type of equipment for different applications. The sales engineer is a link between the instrument repairman and the instrument engineer but, in many cases, he does not come in contact with the instrument man himself but deals with the plant engineer or the plant's instrument engineer.

The duties of an instrument maintenance engineer in a process plant may be as varied as those of the application engineer, but he becomes acquainted with the maintenance problems also.

The combined services of instrument engineers are to see that equipment is designed that can accomplish the desired results and that this equipment is applied to the proper jobs in such a way as to lower costs, to reduce space requirements, to reduce maintenance, and to produce a better product.

When the engineers have completed their work and a plant is built and placed into operation, it falls upon the instrument men to see that the equipment functions properly. It is then that the first signs of instrument engineering getting ahead of instrument maintenance become noticeable. Ordinarily, the instrument man has had only a high-school education; nevertheless it is necessary for him to determine how the engineers have decided that the plant should operate and whether or not it is operating properly. In addition, it is necessary for him to make repairs on complicated instruments of many types. Therefore, training is necessary for instrument men in order that they may keep abreast of new methods and developments.

Among the many ways in which this training can be accomplished, perhaps the most practical is education within the plant. A general discussion of automatic-control actions would show the relationships between different makes of equipment; and a series of lectures on subjects such as "How to Calibrate a Presure Gage" or "Repair and Maintenance of a pH Meter" would explain not only how, but why, certain processdures are followed. In addition, the instrument man should know what the instrument engineer does and how the engineer uses the results of practical experience in his calculations. It would be helpful to take a differential equation and explain, as simply as possible, what the various terms stand for and then indicate how the solution is used to determine instrument characteristics. Such a procedure would even open a new field of instrument engineering to outline and produce courses.

Everyone will agree that the instrument man should be familiar, to some extent, with the same basic fundamentals as the instrument engineer. At any rate, it is certain that the instrument engineers are getting ahead of the instrument men. What can we do about it?

ROBERT TOBI

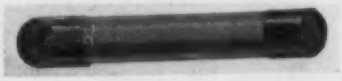
Richmond, Calif.
February 21, 1948

The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.
FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 283

Chromatic Thermoscope

New "Kolor-Therm" indicates temperature by color on electrical appliances, railway journal boxes, chemical



apparatus, motors, etc. Yellow in color at 100°F. (38°C.) or less, it turns gradually from orange to red as temperature increases. Upon comparison with color standards, approximate operating temperature or danger point can be seen. Full red indicates the danger point. "Kolor-Therm" again becomes yellow upon cooling. Made in 190°F. (88°C.) and 250°F. (121°C.) ranges.—*Kolor Therm Indicator Corp., 434 Broadway, New York 13, N. Y.*

Please mention number 301 when filling out card

Refrigeration Pressure and Vacuum Gages

New "Frostline" gages, specifically designed for refrigeration industry, are of portable type and include both a high- and low-side instrument, each available with or without a temperature-equivalent scale. Features include adjustable pointer; removable screw check to prevent damage to Bourdon spring from surges in pressure; luminous treatment of dials and pointers; low-side (vacuum) gage protected to 200-lb. overpressure.—*United States Gauge Div. of American Machine and Metals, Inc., Sellersville, Pa.*

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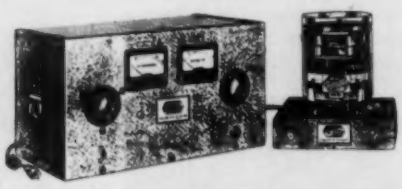
Supersonic-energy Generator

New "Table Model Ultra-Sonorator" is a simplified single-frequency (400-kc.) supersonic-energy generator which operates on any 110 volt a-c. line and



costs about one-third as much as the previously available generator. It comprises two units: (1) the generator, (2) oil bath in which sample is placed. Power generated is believed suitable for most research work. Once instrument is set up, experiments are conducted merely by placing sample (contained in an Erlenmeyer flask or other flat-bottomed vessel) in the "fountain." —*Fisher Scientific Co., 711 Forbes St., Pittsburgh 19, Penna.*

Please mention number 303 when filling out card

Pocket-size Spring Scale

New 20-lb. capacity spring scale is 6" long; has body and head of solid brass, both bright finished. All working

parts are heavily cadmium-plated. Quarter-pound graduations are in bright red enamel. — *Pelouze Mfg. Co., 1228 Chicago Ave., Evanston, Ill.*

Please mention number 304 when filling out card

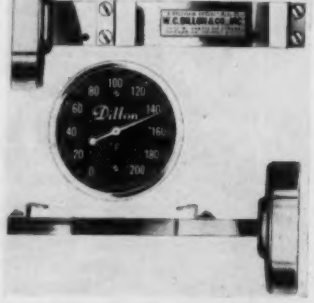
Voltage-reference Tube

New "5651" is an 87-volt miniature voltage-reference tube of the cold-cathode glow-discharge type. It is said that its exceptional stability, not only initially but also throughout life, makes it particularly useful as the voltage-reference tube in d-c. power supplies incorporating electronic voltage regulation. Voltage fluctuation at any current value within operating-current range of 1.5 to 3.5 milliamperes is less than 0.1 volt. Operating characteristic is essentially independent of ambient temperature.—*Tube Dep't, Radio Corporation of America, Harrison, N. J.*

Please mention number 305 when filling out card

Flat-stem Dial Thermometer

New flat-stem dial type thermometer has been designed to clamp primarily onto flat or rectangular surfaces. Ordi-

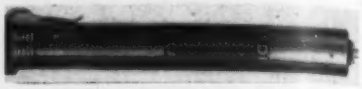


nary "C" clamps will hold it, or it can be drilled and tapped and screwed down in any desirable position. (Illustration shows brackets used to secure it to power bus-bars.) New thermometer can be supplied in flat stems of various metals, widths, thicknesses, and lengths to meet customers' requirements. Standard ranges: 0-200°F., 50-500°F., 150-750°F. and 200-1000°F. Centigrade ranges available on order. 3" and 5" dials are standard. — *W. C. Dillon & Company, Inc., 5410 W. Harrison St., Chicago 44, Illinois.*

Please mention number 306 when filling out card

Pocket-size Signal Generator

New "Pocketracer" for trouble-shooting is ready for use on insertion of a 5-cent "penlite" flashlight cell. Oscilla-

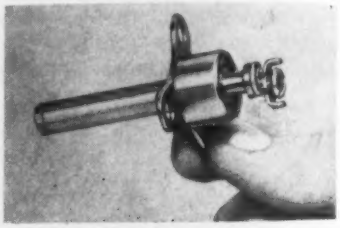


tions radiated from metal tip will be picked up by antenna or other circuits of radio receiver. Radiating signal is said to be highly directional and to extend for several inches around terminal.—*Radex Corp., 2076 Elston Ave., Chicago 14, Ill.*

Please mention number 307 when filling out card

Aircraft Fire Detector

New "CPI Fire Detector" operates fire alarm signal at a preset temperature; actuates alarm under allowable

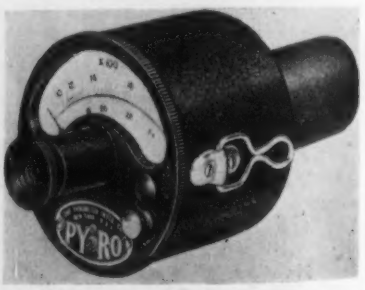


five seconds when exposed to a direct flame of 2000°F. and indicates fire out equally fast. Normally-open circuits (no relays required). Tube length $1\frac{23}{32}$", $\frac{3}{8}$" diam.; over-all length $2\frac{13}{16}$"; weight approx. 1 oz.—*Control Products, Inc., 306 Sussex St., Harrison, N. J.*

Please mention number 308 when filling out card

Radiation Pyrometer

New "Pyro" radiation pyrometer for temperatures above 1000°F., is completely self-contained, weighs less than



2 lbs., is automatic in its operation: sight at object being measured and read temperature. Indicator locking device holds pointer at reading until a button is pushed.—*The Pyrometer Instrument Co., 103 Lafayette St., New York 13, N. Y.*

Please mention number 309 when filling out card

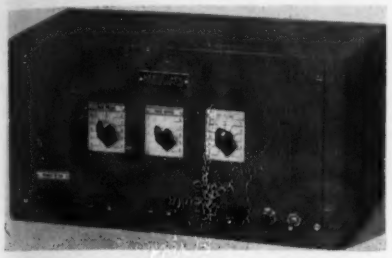
Tube and Circuit Tester

New "Series 10-54 Electronamic Test Master" is a high-sensitivity tube, battery and circuit tester, similar in appearance to "Series 10-20" (fully described in *Instruments*, Nov. 1947, page 1039) but with 35 instead of 34 ranges; and other new refinements.—*Precision Apparatus Co., Inc., 92-27 Horace Harding Blvd., Elmhurst, L. I., N. Y.*

Please mention number 310 when filling out card

Multiple Power Supply

New "Model 103" multiple power supply provides four voltages: two "B" continuously-variable 0 to 300 volts at



currents up to 120 ma., one "C" —50 to +50 volts at 5 ma. and one heater supply 6.3 volts at 5 amps.—*Kepco Labs., Inc., 142-45 Roosevelt Ave., Flushing, N.Y.*

Please mention number 311 when filling out card

Wand-type Conductivity Cell

New "Type VO-1" wand-type conductivity cell may be used as a dip cell or permanently mounted in place, has a body of acid-resistant plastic with handle at one end and flush electrodes of bright platinum at the other. It measures 24″ long by 1″ O.D., and for permanent mounting is provided with a bushing of 1″ pipe size or larger. Design permits easy cleaning of electrode surfaces.—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

Please mention number 312 when filling out card

Two-waveband U-v. Source

New "Dual-Wave Raymaster" is for professional and industrial users of "ultraviolet and black-light radiation either in long or short wave lengths."

Burner employed for radiation at 3600 AU embodies a built-in filter which eliminates most of the visible light; burner for radiation at 2537 AU employs a separate, flat plate filter which confines 90% of output to the 2537 AU wave-band. Unit uses only 12 watts of current (110 volts a.c.).—*Geo. W. Gates & Co., Inc., Franklin Square, L. I., N. Y.*

Please mention number 313 when filling out card

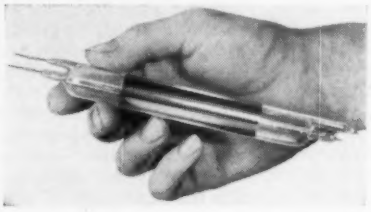
Hardness Testing Machine

New "Model KDR" Brinell Testing Machine capable of checking up to 800 pieces per hour and of parts varying in diameter and thickness as much as ¾″ without moving elevating screw, is motor-driven, hydraulically-operated and so constructed that it is impossible for operator to remove specimen before full load has been applied to penetrator. Load is held for a predetermined time cycle (adjustable from 2 to 15 seconds duration) after which time penetrator reverses, ready for next test. Throat opening 6″; max. vertical opening 14″. Standard equipment includes flat and vee anvils. — *Steel City Testing Machines, Inc., 8843 Livernois, Detroit 4, Mich.*

Please mention number 314 when filling out card

Geiger-Mueller Counter

New "Model D11" Geiger-Mueller counter designed for use with recording instruments is all-glass with a window

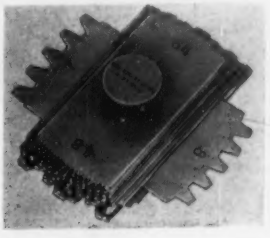


thickness of 25 mg./cm.^{2}. Over-all dimensions are 8″ × ¾″, with an active length of 3″. Cathode material: copper or silver as specified; central wire 0.004″ polished tungsten. New counter is self-quenching "fast-counter" type. A glass skirt at each end of central wire insures a long flat plateau of approx. 250 volts, at a slope of 2% per hundred volts. Threshold voltage is 850 to 950 volts; expected life is 10^8 counts. —*Instrument Development Labs., 228 W. Erie St., Chicago 10, Ill.*

Please mention number 315 when filling out card

Gear Gage

New "Gear Gage Paper Weight" is composed of 12 leaves: 24 gear shapes; 14½° pressure angle but, if desired, 20°

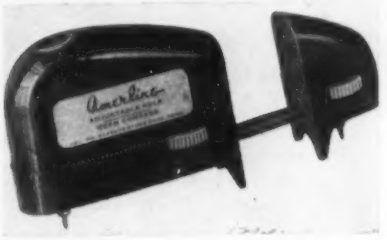


and circular pitch. (Other shapes or templets to special order.) — *George Scherr Co., 200 Lafayette St., New York 12, N. Y.*

Please mention number 316 when filling out card

Beam Compass

New "Amerline Beam Compass and Measuring Rule" is completely self-contained, locks in position to draw cir-



cles up to 12 feet in diameter, is equipped with both lead point and stylus. The 72″ nickel-plated Lufkin steel rule, 3½ oz. weight, and "vest pocket" design make it a multi-purpose instrument that can be conveniently carried.—*Amerline, Inc., 1753 N. Honore St., Chicago 22, Illinois.*

Please mention number 317 when filling out card

Television-receiver Tester

New "Mega-Pipper" is a production and service alignment instrument which, used in conjunction with "Me-

ga-Sweep" or "Mega-Match," makes it possible to quickly and accurately align television receivers. It gives four precise crystal-controlled pips independent of circuit under test. These pips establish the picture, sound carrier, and also adjacent channel points. Weight, 15 lbs.; size 8″ × 16″ × 8″.—*Kay Electric Co., Pine Brook, N. J.*

Please mention number 318 when filling out card

Cement and Concrete Testing Machine

New 300,000-lb. cement and concrete testing machine has 10″ ram stroke. Optional equipment: spherically-seated rectangular compression head; bearing plate large enough to permit testing concrete blocks 12″ wide, 18″ long and 8″ high. Scribed concentric circles on

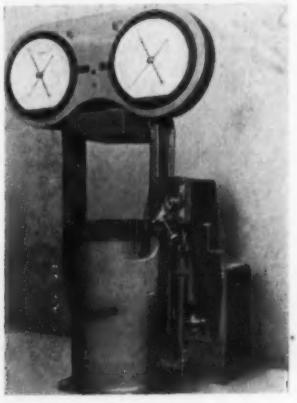


plate make it equally suitable for standard cylindrical specimens. Machine meets A.S.T.M. requirements, and is adapted for use on construction projects, in field laboratories, etc. — *The Baldwin Locomotive Works, Philadelphia 42, Pa.*

Please mention number 319 when filling out card

Gage-block-checking Pneumatic Comparator

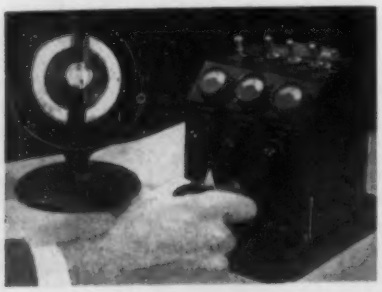
New comparator for checking length of gage blocks by air consists of a gaging unit and a "Precisionaire" base

instrument with an amplifier up to 40,000 to 1. Each minor graduation of scale represents one-millionth of an inch. Master calibrated blocks are used in setting up comparator and obtaining a zero reading. For comparisons of other external dimensions of a less critical nature, gaging unit may be used with "Precisionaire" base instruments of lower amplification.—*Sheffield Corp., Dayton 1, Ohio.*

Please mention number 320 when filling out card

Airplane Gyropilot

New gyropilot is said to be unaffected by any maneuver of plane. It can be set to cause plane to climb or



descend at a given rate, to fly at a fixed level, or to adhere to a prescribed course, thus relieving human pilot. It employs three coördinated gyroscopes, one for each principal axis of motion. These are rate gyros, i. e., responsive to change in angular velocity, fixed to the plane and allowing it to loop the loop and barrel roll, if desired, without loss of control (necessary for pursuit ships). New gyropilot's not being affected by high acceleration rates suggests its possible use on guided missiles and pilotless aircraft, in addition to obvious application to commercial and military airplanes. — *Westinghouse Electric Corp., East Pittsburgh, Penna.*

Please mention number 321 when filling out card

Signal Calibrator

New "Electro-Cal" provides 0 to 1000 mv. in eight continuously-variable ranges; 0-5 volts in one continuously

variable range. Output is a 60-cycle sine wave voltage. Instrument is supplied complete, ready for operation.—*Industrial Electronics, Inc., 21 Henry St., Detroit 1, Mich.*

Please mention number 322 when filling out card

Clipped-wave Signal Generator

New "Sine Wave Clipper," for laboratories interested in audio frequency circuits, provides a test signal particularly useful in examining frequency response and transients of audio circuits. Designed to be driven by an audio oscillator, it provides a clipped sine wave—hence its name. By feeding output of clipper into audio equipment under test and in turn introducing equipment's output into an oscilloscope, operator may quickly view and analyze distortion introduced by amplifier. Typical kinds of distortion viewed on 'scope when testing equipment in conjunction with Clipper are reproduced in instruction book accompanying each Clipper. —*Barker & Williamson, Upper Darby, Penna.*

Please mention number 323 when filling out card

Sweep Generator

New "Type WR-53A" portable FM sweep generator is said to be the first unit of its type designed exclusively

for servicing and alignment of FM equipment. Entire FM band, 88-110 Mc. Terminals are provided for obtaining deflection voltages for use with an oscilloscope when employing visual method. Instrument weighs 15 lbs., measures 13½" × 9¾" × 7½".—*Test and Measuring Instrument Sales, RCA Victor Div., Radio Corp. of America, Camden, N. J.*

Please mention number 324 when filling out card

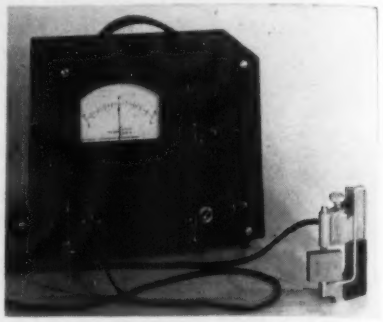
Automatically-timed Photo Copier

New "Tru-Copy-Phote" photo copying machine has 14" × 20" copying surface. Automatic "Time-o-lite" electric timer assures uniform results in any quantity from printed or written copy and photographs. Unit is furnished complete with all necessary accessories, including trays, dryer, paper, chemicals, color filter, red pilot light, squeegee board and glassware. It operates on 115-volt a.c. in ordinary office light without need for darkroom, focusing or heating unit.—*General Photo Products Co., 15 Summit Avenue, Chatham, N. J.*

Please mention number 325 when filling out card

Electronic Micrometer

New electronic micrometer features an exceptionally light measuring head enabling operator to measure a work-

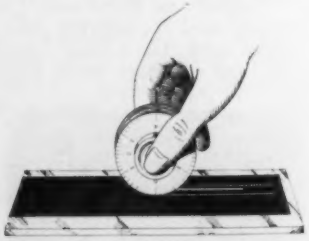


piece in a lathe, grinder, etc.; range 0.0005" or 0.005" (magnification 3000× or 300×) by selector switch. Amplifier is claimed to be free from drift after warm-up time of 30 to 50 seconds. Various micrometer frames; "Norbide" anvils on special order.—*Graham-Mintel Instrument Co., 2443 Prospect Ave., Cleveland 15, Ohio.*

Please mention number 326 when filling out card

Wet Film Thickness Gage

New "Interchemical Direct-reading Wet Film Thickness Gage" is said to be a radically new instrument for



measuring the wet film thickness of paint, varnish, lacquers and related products. It is essentially an eccentric center wheel supported by two concentric wheels. Portions influencing accuracy are machined to 0.001". Instrument measures wet film thickness within a range from 0 to 4 mils with an accuracy of 0.1 mil by simply holding axle of gage between thumb and forefinger, rolling gage over wet film, and reading calibrated engraved scale on side of outer wheel. Speed and accuracy are said to be combined.—*Henry A. Gardner Lab., Inc., 4723 Elm St., Bethesda 14, Md.*

Please mention number 327 when filling out card

D-c. Power Supply

New "Electrox Master Battery Eliminator Model AR-2" delivers 6 volts d.c. free of hum (less than 3% ripple). Turning rheostat adjusts output to 6 volts with any load current between 3 and 15 amperes. It is claimed that "no service or attention is required."—*Rectifier Div., The Schauer Machine Co., 2055 Reading Rd., Cincinnati 2, Ohio.*

Please mention number 328 when filling out card

Wire Strippers

New "Speedex" hand tools strip insulation from all types of wire, are made to strip wire sizes No. 8 to No. 30. Hardened-steel precision-ground cutting blades are interchangeable and can be purchased separately. "Speedex" wire stripper can be used as a production tool on bench or as a portable hand tool. 750 to 1000 wires can be stripped per hour by girls or men. Standard Models strip No. 8 to No. 30 wire; Automatic Models (illustrated) have "stay open" feature for stripping fine standard wires: hold jaws open until wire is removed; can also be used on solid wire; strip No. 8 to No. 30 wire. — *General Cement Mfg. Co., 919 Taylor Avenue, Rockford, Illinois.*

Please mention number 329 when filling out card

Gear Tester

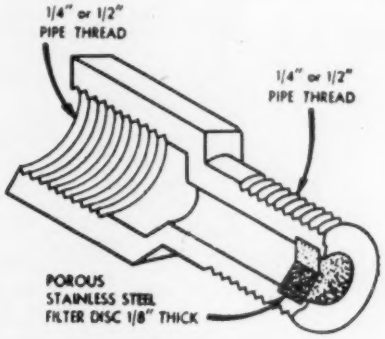
New 9" "Parkson Gear Tester" incorporates improvements over previous models, among them an adjustable

stop-rod in addition to scale and long vernier which are used for setting center distance. Illustration shows a machine set up for spiral gears, but it is also available for spur, bevel, and worm gears, either in combination or single-purpose models.—*George Scherr Co., 200 Lafayette St., New York 12, N. Y.*

Please mention number 330 when filling out card

Pressure Snubbers

New snubbers for eliminating pressure gage fluctuations incorporate porous stainless steel filter disk with large



filter surface which effectively prevents clog-up. Specially designed filter disks are available for air, oil, water, mercury, etc. Max. differential pressure rating of standard types, 500 lbs./in.^{2}; snubbers for use up to 5000 lbs. differential can be supplied.—*Equipoise Controls, Inc., 100 Stevens Ave., Mt. Vernon, N. Y.*

Please mention number 331 when filling out card

Laboratory Bench Unit

New "Open Bench Unit" added to maker's line of "Unitized Laboratory Furniture" makes it possible for laboratories to assemble a series of workbench units which will fit any wall space exactly: it is adjustable in width to make this perfect fit possible, also in height for convenience as support for balances, microscopes and other instruments employed by operator when he is in a sitting position. "Unitized Furniture" line is composed of thirteen basic units.—*Fisher Scientific Co., 717 Forbes Street, Pittsburgh 19, Pa.*

Please mention number 332 when filling out card

pH Meter

New "Industrial pH Meter" is line-operated, direct-reading and continuous-indicating. It includes two stages

of voltage regulation, permitting voltage variations from 80-135 volts, to eliminate difficulties arising out of widely varying factory voltages. Electric circuit has been completely freed from grounding so that electrodes may be used in grounded tanks or flow lines. New instrument may be used for controlling and recording.—*Macbeth Corporation, 227 West 17th Street, New York 11, N. Y.*

Please mention number 333 when filling out card

Electron Diffraction Camera

New electron diffraction instrument differs from x-ray diffraction instrument (which analyzes thick specimens) in that it shows crystal structure of

surfaces and thin specimens up to 500 AU. A beam of electrons is directed at specimen and resulting diffraction pattern photographed. Pattern consists of rings whose diameters, intensities and orientations provide information for determining composition, orientation, and size of crystals present. Instrument consists of one unit containing vacuum chamber with specimen manipulator, visual and photographic recording camera, electron gun and beam focussing elements, regulated high-voltage power supply, and complete vacuum pumping equipment. Specimen chamber permits examination of specimens ranging from 0.1" to 4" diameter. In many cases, instrument will detect and help identify first chemical changes before they are visible under a microscope or are detectable by other means.—*Special Products Div., General Electric Co., Schenectady, N. Y.*

Please mention number 334 when filling out card

Photoelectric Excess-smoke Indicator

New "Type 2A1OC" Excess-smoke Indicator continuously indicates condition of flue gases, signalling when either smoke or air is sufficiently excessive to cause inefficient combustion or create a smoke nuisance. Equipment includes Photoelectric Control "Type 2A1OC," Light Source "Type L3OR," and Densometer "Type D33" (illustrated.) A tamper-proof sensitivity ad-

justment on photoelectric control is set upon installation to compensate for flue dimensions and other variables. Recording equipment to continuously record smoke density is also available for use with this equipment. — *Photoswitch, Inc., 77 Broadway, Cambridge, Mass.*

Please mention number 335 when filling out card

Rubber Hardness Tester

New "Rex Hardness Gage" for measuring hardness of rubber and similar compounds is the size and shape of a

large fountain pen, is operated when an indenter at one end is pressed firmly against surface to be tested; reads in the same units as the Shore Durometer; meets requirements of latest ASTM rubber hardness test method. — *United States Rubber Co., Rockefeller Center, New York City.*

Please mention number 336 when filling out card

Carbon-monoxide Detector

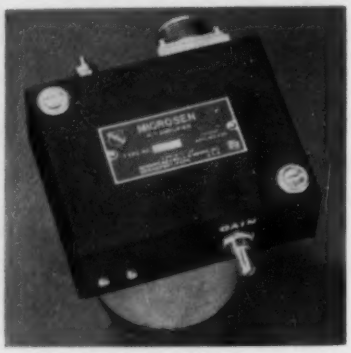
New "M.S.A. Carbon Monoxide Tester," utilizing colorimetric-method indicator tubes developed by the Na-

tional Bureau of Standards, requires no special training to use, is capable of indicating presence of CO from 0.001% to 0.1% by volume in air. Operation: sealed ends of detector tube (containing a yellow chemical) are broken in tube-breaker and tube inserted into instrument tube-holder. A sample of the air is aspirated by squeezing bulb. If air sample contains CO, yellow indicating chemical turns varying shades of green, directly proportional to CO concentration; degree of discoloration is then compared with instrument's integral revolving color scale.—*Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.*

Please mention number 337 when filling out card

D-c. Amplifier

New "Model 143AT2" d-c. amplifier for low level signals in telemetering utilizes "Microsen Balance" principle;



has a time constant of 0.02 second; adjustable gain setting of 160 to 300. Max. input voltage 0.2 volt; output voltage of 0 to 5 volts; power required 5 watts. Size is 40 cu. in., weight 24 oz. New unit in general is designed to be used with other electronic equipment all of which is vibration- and shock-isolated. With limited changes, it can be used to drive an indicator, for control circuits, or as a high-sensitivity relay.—*Manning, Maxwell & Moore, Inc., Bridgeport 2, Conn.*

Please mention number 338 when filling out card

Laboratory Detergent

New "Cutscum" liquid detergent is a "soapless" soap in concentrated form particularly recommended for washing laboratory glassware. It cannot form insoluble precipitates with calcium and magnesium. Its pH value of 6.3 makes it entirely harmless to the hands. "Cutscum" is furnished in 8-oz. bottles and only 3 ml. is required for 2 gal. of wash water.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.* and *Eimer & Amend, 635 Greenwich St., New York 14, N. Y.*

Please mention number 339 when filling out card

Solution-stirring Mixer

New small stirring mixer for all fluids will handle containers from one quart to five gallons; is provided with 110-volt

a-c. motor, Underwriters' Laboratory approved electrical connection, including on-and-off switch. Fully rustproofed.—*Dayton Rogers Manufacturing Co., 2835 12th Ave. South, Minneapolis 7, Minn.*

Please mention number 340 when filling out card

Radiation Survey Meter

New version of recently-declassified "Cutie Pie" is a portable ionization type beta-gamma radiation meter said to be especially useful for "hot lab" work where radioactivity of order of millicuries is handled. Instrument weighs less than 5 lbs. Power is supplied by small batteries mounted in a replaceable Lucite enclosure. Three full scales of approx. 100, 1000, and 10,000 milliroentgens per hour provide wide range of dosage rate measurement. A thin window at end of ionization chamber permits entry of beta particles with energies much less than 0.1 Mev, and a permanently mounted ¼" thick rotary Bakelite shield can be slid in front of window to effectively eliminate beta radiation.—*Tracerlab, Inc., 55 Oliver St., Boston, Mass.*

Please mention number 341 when filling out card

Voltage Tester

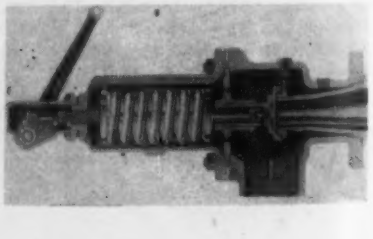
New Voltage Tester is designed for testing continuity of a-c. or d-c. circuits 110 to 550 volts a.c., 110 to 600

volts d.c., blown fuses, grounded side of line, grounded side of motor or appliance, excessive leakage to ground, frequency (25 or 60 cy.) and d-c. polarity. Indications are by a solenoid indicator and a neon test lamp. This gives double protection: each operates independently of the other. Scale is calibrated from 110 to 600 volts. Overall length is 6". Test prod handles are 4" long. Test prods are 2 ft. long. Comes complete in carrying case with belt clip. Weight, 8 oz. — *Ideal Industries, Inc., 1420 Park Avenue, Sycamore, Ill.*

Please mention number 342 when filling out card

Safety-relief Valve

New "Type #2680" safety-relief valve, for handling inlet pressures up to 2000 lbs. and temperatures up to 900°F. and for handling corrosive



Are you LOSING MONEY every day?

IT may be costing you plenty not to have an accurate check on the efficiency of your major processing units. And that's what the new Taylor Integrating Flowmeters (Aneroid or Mercury) can do for you. Automatic totalizing provides you with an accurate comparison of fluid through-put to yield of finished product. In addition, these dependable instruments give accurate cost data on departmental steam consumption for heating and processing. And they detect any abnormally high steam consumption caused by faulty operation of traps or valves.

First the manometer precisely measures the rate of flow. Then the Taylor Square Root Integrator accurately totalizes the flow of liquids, and of gases and steam under constant pressure. The Integrator is easy to read through a large (2-inch) window in the case door. Dependable, synchronous motor drives counter through positive clutch without the use of ratchets. Continuous check on accuracy of calibration at any point of range. Both Oilite and ball bearings for long life. Few moving parts; permanently lubricated cam rollers, self-lubricated bushings; positive, oil-proof counter clutch.

For full details, ask your Taylor Field Engineer. Also ask him about the new Taylor Aneroid (mercury-less) Manometer, with no mercury, no pivots, no stuffing box! Write for Catalog 98175. Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.*

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

Century

GALVANOMETERS

Available with natural frequencies from 15 c.p.s. to 1500 c.p.s., electromagnetically damped and to sensitivities as high as 2" per microampere at 1 meter focal distance.

CENTURY TUBULAR TYPE GALVANOMETERS

The Model G-14 in hard chrome plated brass tube and the Model 205 of heat-treated, non-magnetic stainless steel. Rugged and durable, yet possesses extreme sensitivity. Internal suspensions are manufactured by a patented process which provides unequaled balance. Hermetically sealed giving maximum efficiency under all climatic conditions.

Century

CENTURY GEOPHYSICAL CORPORATION

Tulsa, Oklahoma

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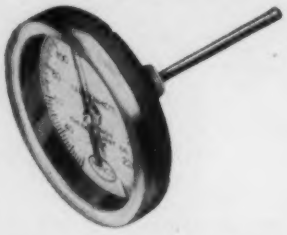
World's Largest Manufacturer of Geophysical and Special Galvanometers

liquids, vapors or gases, is made of cast steel with stainless steel trim. 2½-to-1 guide ratio of disk guide assures full lift and positive reseating. Manufacturer states that capacity has been certified by test at National Board of Boiler and Pressure Vessel Inspectors Laboratories. Combination of nozzle and inverted cone or secondary nozzle is said to make maximum use of kinetic energy of discharge to effect high lift and full capacity, without need of adjustments. Maker states that this fact, coupled with a coefficient of flow efficiency established at 97½, means that a smaller valve can be used. New valve is available in sizes from 1½" × 2" to 6" × 8". Parts of valve are completely interchangeable.—*Farris Engineering Corp., 552 Commercial Avenue, Palisades Park, N. J.*

Please mention number 343 when filling out card

Dial Thermometer

New "Easy-Setting" bimetallic-actuated dial thermometer has case supplied with either a moisture- and fume-

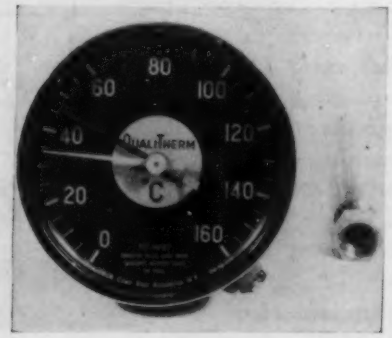


proof frame (assembled with socket-head screws) or a quick-opening threaded frame that may be unscrewed with the fingers. With either type, adjustment of both dial and pointer within full 360° may be made from front while instrument is in service. No tools other than a small Allen wrench and an ordinary screwdriver are required. 4" dial is available in eleven standard scales, covering a total range of −100 to 850°F. or C. equivalent, with an accuracy of 1% of range. Four standard stainless-steel stem lengths: 4", 6", 9", 12". Separable sockets for these stem lengths can be furnished in standard metals.—*Precision Thermometer & Instrument Co., 1475 Brandywine St., Philadelphia 30, Pa.*

Please mention number 344 when filling out card

Transformer Thermometer

New high-visibility transformer temperature indicator assures accuracy in reading under worst conditions by high visual contrast between bright yellow hands and numerals, and blue-gray

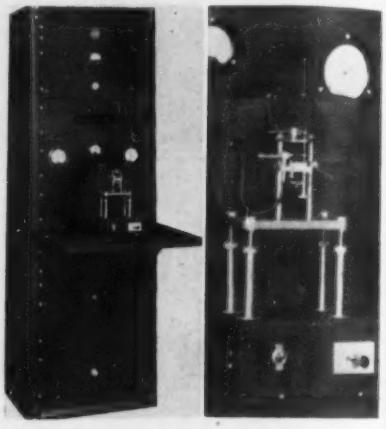


background. Scale is uniform. Oil-tight mounting well permits removal and installation of unit without changing oil level or disconnecting transformer. Maximum-temperature indicating hand is red; is reset by wiping a small magnet over face of cover glass. (This magnet is secured on a light chain to prevent loss; between resettings it is screwed into a hub in side of instrument for safekeeping.) New instrument can be furnished with a predetermined-temperature alarm contact.—*Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.*

Please mention number 345 when filling out card

Hairspring-vibrating Equipment

New Hairspring-vibrating Equipment automatizes many operations now performed manually (but not always reliably) by highly-skilled workers. Bal-

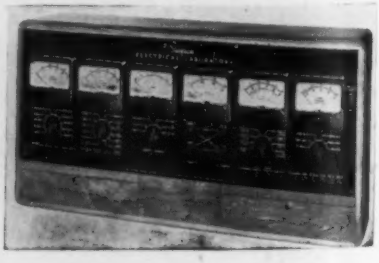


ance-wheel is mounted in a fixture which permits hairspring to be lengthened or shortened until correct rate is indicated, when hairspring is crimped to locate exact pinning point. Equipment consists of three "groups": (1) Frequency or Time Standard accurate to one part per million; (2) Hairspring Vibrator with special optical system, photocell, stroboscope panel, etc.; (3) Tick Amplifier and Printer for adjusting assembled watch movements to correct rate. Production per 8-hour day: more than 700 balance wheels per vibrator; 500 watch movements per printing unit (but one man can operate four printers).—*Gibbs Div., George W. Borg Corp., Delavan, Wis.*

Please mention number 346 when filling out card

Multi-range Electrical Tester

New "Model 1005 Electrical Laboratory", announced as a complete test unit for use in laboratories, shops or service departments, is said to com-



bine the functions of more than sixty separate instruments. It consists of six individual 4½" rectangular instruments, each with a complete set of ranges. In addition to a-c. and d-c. voltage and current ranges: a multirange ohmmeter; a single phase wattmeter; an instrument with a sensitivity of 50 microamperes, providing 20,000 ohms per volt on all d-c. voltage ranges; a rectifier type a-c. voltmeter with a resistance of 1,000 ohms per volt on all ranges, this latter instrument having in combination a complete coverage of db ranges from 10 to + 55 for volume indications. Dimensions approx. 34" × 17" × 9"; weight 37 lbs. — *Simpson Electric Co., 5200 Kinzie St., Chicago 44, Ill.*

Please mention number 347 when filling out card

Pocket Dosimeter

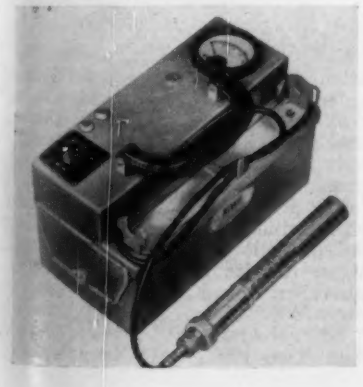
New "Model 3360" Pocket Dosimeter provides easily-read indication of amount of radioactivity to which car-

rier of instrument has been exposed. It can be read at any time by looking through cupped eyepiece toward a light source: observer sees a magnified scale upon which an indicating line shows, in milliroentgens, amount of radiation to which instrument has been exposed. Light-weight aluminum housing does not distort appreciably free-air reading. A molded, flake-proof, conducting plastic cathode surrounds ion chamber, and anode comprises a highly sensitive fused quartz fiber, 5 microns in thickness. Molded polystyrene insulators with optically smooth surfaces reduce leakage and increase instrument accuracy. — *Instrument Development Labs., 229 West Erie Street, Chicago 10, Illinois.*

Please mention number 348 when filling out card

Radiation Meter

New "Model MX-5" radiation meter is a portable Geiger-Mueller counter weighing 9 lbs., for measurement of x, beta, and gamma rediations. It is said to be ideal for measurement of radioactivity of low intensity and, being completely waterproofed (case desiccated) is suitable for use in humid climates, in wet weather and on board ships. "MX-5"



This Oscillograph draws an INSTANT picture of electrical impulses!

Today when saving time costs is so important, your best bet for an *immediate* picture of electrical impulses is with Brush Oscillographs. No more delays with photographic development. *Instantaneous*, permanent, ink-on-paper recordings by Brush Oscillographs make their use almost unlimited. Accurate recordings of strains, pressures and countless electrical phenomena can be made over a frequency range of D.C. to 100 c.p.s. Today Brush Oscillographs are available in Single, Double and Six Channel models. The magnetic Pen Motor is available separately for incorporation into equipment such as medical, geophysical and other highly specialized designs. Whenever desired, recordings may be stopped for notations on chart-paper.

Brush Model BL-913 D.C. Amplifier. Well adapted to the measurement of static or dynamic phenomena such as temperature, light, pressures, strains, etc.

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PORTABLE WIDE-RANGE FLOW TESTING KIT

FOR LABORATORY RESEARCH AND FIELD FLOW RATE CHECKING WORK

VERSATILE
ACCURATE
INEXPENSIVE

"C-Clamp" FLOWRATOR meter kit. The meter is provided with a convenient carrying handle, base plate and hose connectors.
NET PRICE.....$84.50

Practically any laboratory or field problem that requires an accurate determination of the flow rates of liquids or gases is readily handled with the versatile F&P FLOWRATOR (formerly called Rotameter) flow meter kit.

The new "C-Clamp" FLOWRATOR instrument kit consists of an extremely flexible combination of one meter, four metering tubes and six readily identified floats. The selection of proper tube and float combinations is simplified. The "C-Clamp" meter construction permits easy disassembly for quick metering tube changes. Capacities from 0.065 to 2200 cc/min. of water and 5.0 to 36,800 cc/min. of air are covered.

FISCHER & PORTER CO.
DEPT. 8N-5C HATBORO, PA.

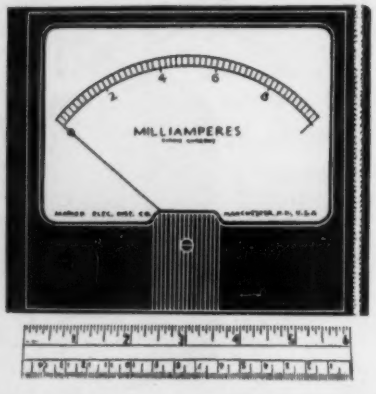
FLOWRATOR
TRADE MARK

is battery-operated, with self-quenching GM tube mounted on a 3-ft. probe. A selector switch gives three ranges: 20, 2 and 0.2 mr/hr. New type circuit is said to eliminate zero control, to feature rapid response and to extend battery life to 400 hours.— *Beckman Instruments, National Technical Labs., South Pasadena, Calif.*

Please mention number 349 when filling out card

5½"-scale Electrical Instruments

New "Model 56" rectangular Bakelite-cased instrument measures 6½" × 5¼"; fills gap between 4½" and 8" instruments; has a 100° arc, 5½"

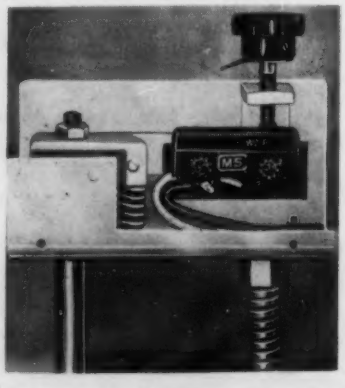


scale length and large open face making it easily adaptable to multi-arc dials. Bakelite case is designed with extra-heavy cross sections for severe service. Versatility is augmented through use of Alnico II magnets in all normal ranges and Alnico V in microammeter ranges.—*Marion Electrical Instrument Co., Manchester, N. H.*

Please mention number 350 when filling out card

Temperature Controller

New "Model L Temperature Switch" was developed in conjunction with a large user of nut roasting machines;

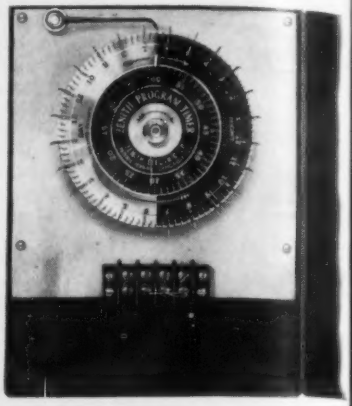


is essentially a production unit; has a normal maximum temperature of about 350°F. but can be supplied for higher temperatures as well. For low temperatures, operating differential is ±0.5°; at highest temperature it is ±2° to 5°. Instrument is available as shown in illustration, with flexible conduit and twist lock clip, or with other types of plug-in connectors as specified. —*Burling Instrument Co., 253 Springfield Avenue, Newark 3, N. J.*

Please mention number 351 when filling out card

Program Timers

New "P-15-24" program timer can be set to sound a bell or other signal at 15-minute intervals for twenty-four hours

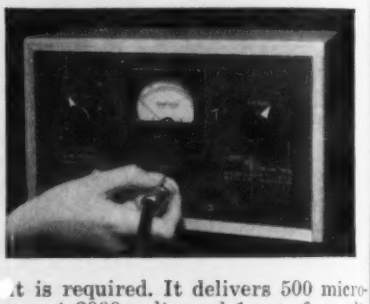


a day; is set in a moment by turning the minute hand as with an ordinary clock. Circuit closure will give signal of 2 to 60 seconds duration as desired. Also announced is new "PR-15-24," for use where it is desired to control radio programs, record players, etc.— *Zenith Electric Co., 152 W. Walton St., Chicago 10, Illinois.*

Please mention number 352 when filling out card

High-voltage Power Supply

New power supply is designed for use wherever a 500- to 2000-volt source of regulated high voltage at low current is required. It delivers 500 microamps at 2000 volts and 1 ma. for voltages up to 1500. Regulation within 1% for ±10% line voltage variations and load variations up to maximum rated load. At any voltage setting, drift is within 0.1%. Six miniature tubes are used. Oak cabinet measures 7½" × 12" × 5¼" deep. Weight, 9½ lbs.— *Atomic Instrument Co., 180 Charles St., Boston 14, Mass.*



Please mention number 353 when filling out card

Engine Wear Recorder

New "Power-recorder" records cumulative power-hour units turned out by an engine, thereby provides measurement of total engine wear. It computes total power-hours produced by continuously measuring engine speed, manifold pressure and atmospheric pressure. Power data are obtained in accordance with engine power curves for all throttle and propeller pitch settings and altitudes. Results are given in terms of equivalent hours at cruising power. In aircraft rental operators, customers can be accurately charged for engine-service time. Two types: (1) with a flexible

shaft connection to engine tachometer outlet; (2) remote-operating type electrically driven by a tachometer generator mounted on engine tachometer outlet. For uses other than aircraft, device can be calibrated in any convenient units, such as horsepower-hours. It prints cumulative power units and engine identification number in the manner of a timeclock, but can be supplied with counter-type register.—*Kollsman Instrument Div., Square D Co., Elmhurst, N. Y.*

Please mention number 354 when filling out card

Time Switch

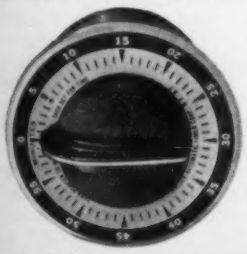
New "Type S" Time Switch approx. 3" wide, 5⅜" high and 3" deep, is powered by a newly-developed high-

torque synchronous self-starting low-speed motor lubricated for life. Switch is designed for easy mounting on a standard switch box, or for surface mounting on any wall; is available in ivory or brown: metal base color matched to plastic cover. — *Sangamo Electric Co., 1022 Converge Ave., Springfield, Illinois.*

Please mention number 355 when filling out card

Automatic Timer

New "1500 Series" timer, designed for built-in use, is equipped with normally-open silver contact switch,



Underwriters' Laboratories rated at 20 ampere 115 volt, 10 ampere 230 volt; is available in 30-, 60- and 120-minute range models. Clock-operated mechanism, of standard lever-escapement type, is operated by means of a Bakelite pointer which, when turned to an interval, closes switch circuit and starts timing mechanism. (For short interval settings, pointer is turned to

FOR FLIGHT RESEARCH

Specially developed for recording in flight, the TYPE S12-A OSCILLOGRAPH and the TYPE OA-2 GALVANOMETER are ideal for operation under acceleration or vibration.

The TYPE S12-A OSCILLOGRAPH is a complete instrument with internal governor motor, gear-driven record, timing device, record numbering, automatic record-length control, and record footage indicator. Rigid cast aluminum case has carrying strap, measures only ten inches wide by 18 inches long, and weighs only 35 pounds.

Fully described in Technical Bulletin SP-167 B

The TYPE OA-2 GALVANOMETER can be supplied in 66 different combinations of sensitivity and natural frequency, for accurate recording up to 6000 cycles per second. The OA-2 is the only galvanometer suitable for use under extreme vibration or acceleration.

Fully described in Technical Bulletin SP-156 B

The TYPE MRC-12 STRAIN GAGE CONTROL UNIT is the smallest complete six-channel static-dynamic strain gage amplifier and balancing unit in existence. Complete with carrying strap, batteries, six amplifiers, six balancing boxes, and 2000-cycle oscillator, the MRC-12 weighs only 42 pounds.

Fully described in Technical Bulletin SP-177 B

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INSTRUMENT COMPANY
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The New

XACTLINE

STRAIGHT LINE TEMPERATURE CONTROL

For Use With Pyrometer Controllers

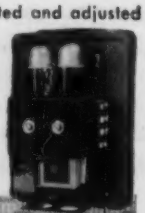
Anticipates Temperature Change Eliminates Overshoot and Undershoot

Now with XACTLINE Straight Line Temperature Control you can increase the efficiency of your Pyrometer Control Instruments (either Millivoltmeter or Potentiometer Type) to an amazing degree. Now you can hold tolerances as close as 1/5°F. plus or minus and power "on-off" cycles as low as 3 seconds.

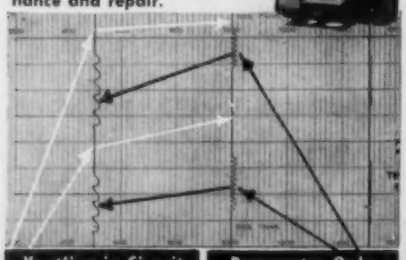
For XACTLINE, operating in the thermocouple circuit, ANTICIPATES the most minute heat variations on both heating and cooling cycles, thereby enabling your pyrometer controller to control far more closely than otherwise possible.

This *Anticipation Factor* means that XACTLINE causes the conventional pyrometer controller to respond to a millivoltage impulse up to 90% less than that normally required, (the controlling pyrometer functions *only* when the desired temperature range has *already been exceeded*).

XACTLINE is laboratory tested and adjusted . . . does not require readjustment or coordination with other controllers.



NO gears, cams, shafts, bearings or other rotating or sliding parts. Simple design eliminates usual maintenance and repair.



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PRECISE CONTROL FOR . . . Tempering-Drawing . . . Iso-Thermal Quenching . . . Al and Mg Treatment . . . Accurate Heat Treating . . . Sintering . . . Metallic Baths . . . Plastic Molding . . . and other operations . . . Price complete F. O. B. Factory . . . $79.50

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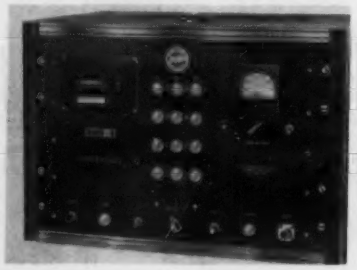
star on dial and then returned for the actual timing period required.) Switch mechanism is mounted on inner side of a Bakelite base, with screw terminals on outer side for wiring connections. Dimensions: $2\frac{3}{16}$" diam., $1\frac{15}{32}$" depth. — *Walser Automatic Timer Co., 420 Lexington Ave., New York 17, N. Y.*

Please mention number 356 when filling out card

Decade Scaler

New "Model 2092" Decade Scaler for radioactivity measurements is completely self-contained; features easy-to-

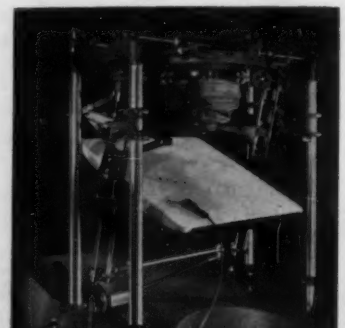


use decimal scale registration; includes three scale of 10 counter decades, a four-digit mechanical register, control for a clock timer and an adjustable high-voltage regulated power supply for operation of Geiger Mueller tubes. Selector switch for scale of 10, 100 or 1,000 in driving mechanical register. New Scaler will resolve two pulses 5 microseconds apart and will count continuously with absolute accuracy at rates up to 130,000 counts per second. Pulse height selector is set at 0.25 volt sensitivity. — *Potter Instrument Co., Inc., 136-56 Roosevelt Ave., Flushing, N. Y.*

Please mention number 357 when filling out card

Automatic Photogrammetric Rectifier

New automatic focus rectifier for mosaic map making simultaneously enlarges, prints and automatically reduces



aerial photographs to a common scale and level, correcting tilt encountered as a result of plane's variation in angle and level at the time photographs are taken. Instrument can be operated by a photographer, turning out rectified prints on a production line basis at the rate of one every five minutes.—*Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.*

Please mention number 358 when filling out card

Combustion-testing Kit

New "Fyrite Combustion-testing Master Kit" contains "Fyrite" CO_2 indicator, "Model MZF" draft gage, and

"Tempoint" stack thermometer (all of which have been described in these columns.) This instrument assortment is said to provide combustion-testing equipment of broadest possible versatility, suitable for use by heating contractors serving commercial and industrial customers, as well as the residential trade. —*Bacharach Industrial Instrument Co., 7000 Bennett Street, Pittsburgh 8, Pa.*

Please mention number 359 when filling out card

Total-temperature Probe for Flight Tests

New "Type 4915 Autoflight Adiabatic Temperature Probe," for use in flight tests of guided missiles, radio-controlled planes, etc., in speed ranges

above 400 mph., was designed by Dr. W. L. Howland, chief of Lockheed flight instruments research staff. It simplifies data reduction by measuring total air temperature (ambient air temperature plus 100% of temperature rise due to velocity. Total time to complete a flight-test is also reduced since the test-aircraft does not slow down for temperature readings. Features: (1) all the velocity energy is converted to temperature; (2) instrument readings are protected against conduction losses and radiation inaccuracies by proper shielding design. Probe is about 6" long and 1" in diameter; can be boom-mounted or strut-mounted with a small air-foil section (supplied by manufacturer). In operation, air enters nose of probe and flows around a resistance bulb, or thermocouple.—*G. M. Giannini & Co., 285 W. Colorado St., Pasadena 1, Calif.*

Please mention number 360 when filling out card

Liquid Level Indicator

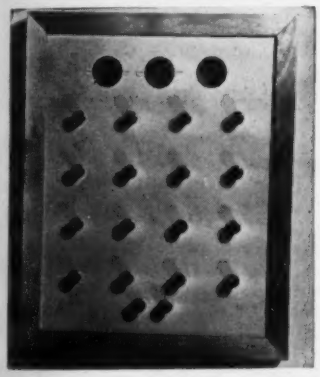
New magnetic-type liquid-level indicator consists of two separate, independently replaceable assemblies, each

oil-tight and weatherproof. Outer assembly includes calibrated dial and indicating needle directly mounted on a shaft carrying a powerful magnet. Bezel covers and protects mounting screws with which body is attached to tank wall. Body is a sealed unit enclosing another powerful magnet mounted on float-arm shaft. Instrument can be furnished with an alarm contact for low-level indication. — *Westinghouse Electric Corp., East Pittsburgh, Penna.*

Please mention number 361 when filling out card

Electronic Circuit Panel

New "Model 104" electronic circuit panel, for ease in performing experiments, enables student to investigate



tube and circuit characteristics, comprises three octal tube sockets and eighteen binding posts; is supplied with twenty-three circuit diagrams designed to be placed on panel, also blank keyed sheets for designing circuits. Panel is 12¾" × 10¼"; sheets are 11" × 8½". —*Kepco Labs., Inc., 142-45 Roosevelt Ave., Flushing, N. Y.*

Please mention number 362 when filling out card

Sweep Calibrator

New "Model GL-22" Sweep Calibrator is a pulsed timing marked oscillator designed for use with standard oscilloscopes and synchroscopes for accurate measurements of time intervals on

Speedy • Accurate

RESISTANCE MEASUREMENTS

. . . with the Rubicon
PORTABLE WHEATSTONE BRIDGE

This convenient instrument combines instant portability with high accuracy and is widely used in laboratory, plant and field. Built for dependable service under hard usage.

- Wide range: 1 ohm to 10 megohms
- Limit of error: 0.1%
- Built-in battery and galvanometer
- Provision for external battery and galvanometer when required
- Available with Murray and Varley loop circuits
- Compact and rugged

. . . with the Rubicon
PORTABLE KELVIN BRIDGE

For work at very low resistance levels this instrument is the counterpart of the Wheatstone bridge shown above.

- Range: 0.0001 to 10.1 ohms
- Limit of error: 0.25%
- Built-in battery and high sensitivity "Pointerlite" galvanometer
- Provision for external battery and galvanometer when required
- Sturdy and convenient in operation

Wheatstone and Kelvin bridges in a variety of models, together with other resistance measuring instruments, are fully described in Bulletin 100 available on request.

SPOTLIGHT GALVANOMETER

- Sturdy, short period
- Sensitive (up to 0.0006 μA per mm.)
- Multiple-reflection optical system
- For null or deflection measurements

Described in Bulletin 320

OTHER RUBICON INSTRUMENTS

Resistance Standards • Mueller Bridges • Precision Potentiometers • Evelyn Photoelectric Colorimeter for chemical analysis • Automatic Recording Photometric Analyzers for NO and H_2S • Magnetic Permeameters • Magnetic Hardness Testers • Shorted-Turn Coil Testers • Other equipment involving precise measurement of electrical quantities.

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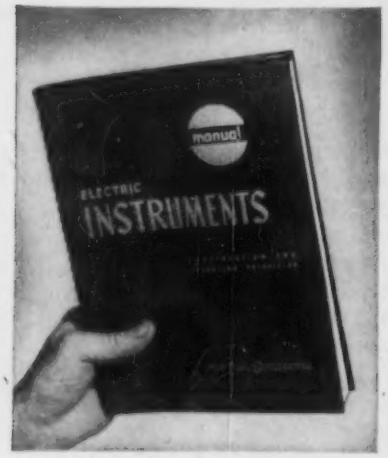

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GE Manual of Electric Instruments

Have you ever wondered just how an oscillograph works, or what a Gauss Meter is? You can find the answers to these and many other questions in the New G-E Manual of Electric Instruments—a publication that has required several years of preparation and has just been released for general distribution. Loaded with information on the construction and operating principles of various electric instruments used in industry, this manual is an invaluable reference.

The seven compact sections give detailed information on these classifications of electric instruments:

1. Permanent-magnet Moving-coil Instruments
2. Rectifier and Thermocouple Instruments
3. Moving-iron Instruments, Ammeters and Voltmeters
4. Electrodynamometer Instruments
5. Power-factor Meters, Synchroscopes, and Frequency Meters
6. Recording Instruments
7. Specialized Instruments

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GENERAL ELECTRIC

602-119

either triggered or recurrent sweeps. Variable amplitude markers of either polarity are provided with sufficient amplitude for use as intensity markers or directly on cathode-ray tube plates as deflection markers. Markers available are 0.1, 0.5, 1.0, 10, 100 microseconds. A positive or negative variable-width gate pulse output is provided for test purposes; duration of this pulse corresponds to duration of marker group. Operation of calibrator may be by use of external synchronizing triggers or from its own trigger generator with output triggers of both polarities available at front panel connections. Dimensions, 14" × 7" × 7"; weight, 20 lbs.—*Browning Laboratories, Inc., Winchester, Mass.*

Please mention number 363 when filling out card

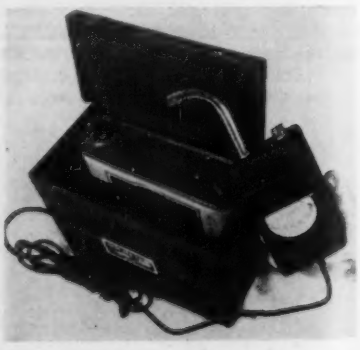
Log-scale Megohmeter

New direct-reading megohmeter has logarithmic scale distribution which results in utilization, with the same accuracy, of the full range of 1 to 100,000 megohms covered by six decade steps. Potential is applied to sample during measurement only, by means of a safety switch. Provision for use of external voltages on sample extends range to 1,000,000 megohms. Charging position is included in range switch for facilitating measurements on items having large capacitance. Oak cabinet dimensions 11½" × 8½" × 7".—*Macleod & Hanopol, Chelsea and Joiner Sts., Charlestown 29, Mass.*

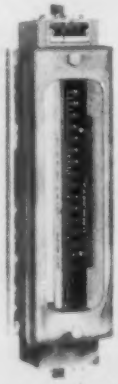
Please mention number 364 when filling out card

Air Velocity Meter

New model of maker's "Air Meter" will, it is said, measure accurately velocities as low as 5 fpm. It utilizes noble-metal thermopile principle; in-



The Full-View
ROTAMETER



The list grows

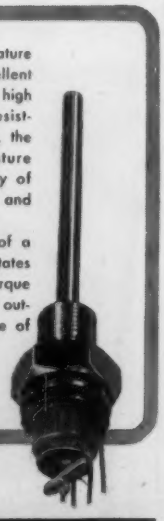
Day by day, the list of users of the Full-View rotameter grows. Today it contains the best names in the Process Industries. The reasons: lower maintenance, better corrosion resistance, greater safety and higher accuracy. For details, write for Folder No. 20.

BROOKS ROTAMETER CO.
BOX A-5348 LANSDALE, PA.

TEMPERATURE TRANSDUCER
from −65°c to +150°c

Latest type Giannini Temperature Transducer combines excellent range, large outputs and high accuracy. Available in resistances up to 20,000 ohms, the new type 4911 Temperature Transducer has a linearity of 1%, an accuracy of 1%, and a sensitivity of 1° C.

The instrument consists of a bi-metallic element that rotates a standard Giannini Microtorque Potentiometer for electrical outputs. This instrument is one of thirty basic Giannini developments in the telemetering field.



Write for complete engineering details.

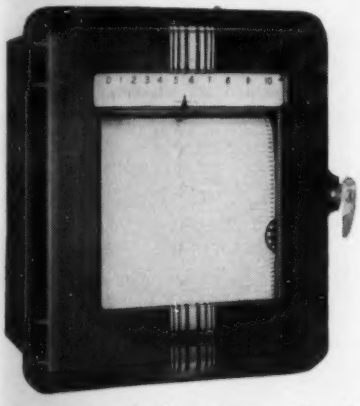
G. M. Giannini & CO. INC
REACTION POWER PLANTS • AUTOMATIC FLIGHT EQUIPMENT
293 WEST COLORADO STREET • PASADENA 1, CALIFORNIA

corporates a larger, more accurate indicator; features an increase in standard range of the instrument from 2000 to 6000 fpm. with no sacrifice in accuracy of low-velocity measurements: lower half of scale is expanded for accurate reading of velocities from 0 to 200 fpm. while upper half is compressed logarithmically for readings up to 6000 fpm. Instrument may be operated from a 110-volt a-c. outlet or from a portable battery-operated power pack. Thermopile is installed in a ½"diameter probe which may be plugged directly into case, placed on an extension wand, or installed at a remote location. — *Hastings Instrument Co., Inc., Hampton, Va.*

Please mention number 365 when filling out card

Oxygen Recorder

New "Micromax" oxygen recording equipment handles applications beyond scope of CO_2 recorders; serves as a

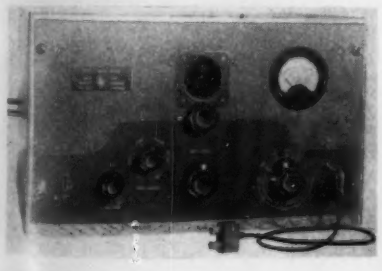


guide for regulating excess air, also for checking combustion in boiler furnaces which fire several different fuels simultaneously or in succession. New recorders utilize thermal conductivity principle, specifically the "hydrogen-difference" method which consists of adding hydrogen to gas sample, removing oxygen by combustion, and electrically comparing conductance of sample before and after oxygen is removed. Because all parts which contact gas are made of glass, equipment is corrosion-proof and stable in calibration. Instrument is available in two models; for extra visibility of scale, a round-chart "Micromax"; for a highly detailed record, a strip-chart model (illustrated). —*Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.*

Please mention number 366 when filling out card

Wide-range Oscillator

New "Model 650A Resistance Tuned Oscillator" is said to be the first commercial instrument of its kind to provide audio measurement speed, ease and accuracy for readings at r-f, video



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PRESSURE-SENSITIVE INSTRUMENTS

—fitted to your individual needs

A & M gauges, for measurement of pressures of gases or liquids in the low pressure range, afford great sensitivity and accuracy. This is achieved by use of a new material in the capsules which improves the very heart of the instruments. A & M offers numerous adaptations with custom calibration to fit a wide variety of applications.

We offer you a superior instrument at a reasonable price and invite you to write for further descriptive material, stating your particular needs.

AIRPLANE & MARINE INSTRUMENTS, INC.

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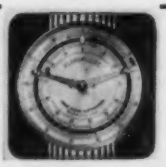
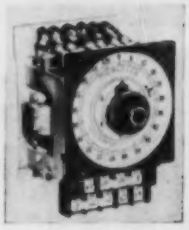
EAGLE TIMERS for Controlling Industrial Processes

REPEAT CYCLE
Use where ON-OFF operation is continuously repeated. The ON time and OFF time are each adjustable on the dial. (FLEXOPULSE)





MICROMETER DIAL
Provides exceptional timing accuracy where a circuit is to close or open with a time delay. Timing adjustable over wide range. (MICROFLEX TIMER)

COUNTER
Use for limiting a process to an exact number of operations. The counter contact opens after 1 to 400 electrical impulses as selected on dial. Automatic spring reset. (MICROFLEX COUNTER)

MULTIPLE CIRCUIT —ADJUSTABLE
Use where several circuits are to close in a predetermined sequence. Time of closing and opening each circuit is adjustable. (MULTIFLEX TIMER)

To reduce costs and improve quality of your products by automatic TIME-COUNT control . . .

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- ★ Send for details of your control problems to Eagle for recomendations.
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EAGLE Signal Corp.
MOLINE ILLINOIS

and audio frequencies. Frequency range 10 cycles to 10 Mc. in decade ranges. No zero setting required; minimal adjustments during operation. Voltage range 30 microvolts to 3 volts. Output impedance 600 ohms, but a 6-ohm impedance is also available through an output voltage divider supplied with instrument. Other features: 9" scale length, 6-to-1 micro-controlled vernier tuning drive and a complete VTVM to monitor output in volts or db at 600-ohm level. Operation is from 115-volt a-c. power supply. Relay rack or cabinet mounting; panel size 19" × 10½"; instrument is 13" deep. — *Hewlett Packard Co., 395 Page Mill Road, Palo Alto, Calif.*

Please mention number 367 when filling out card

20-ampere Autotransformer

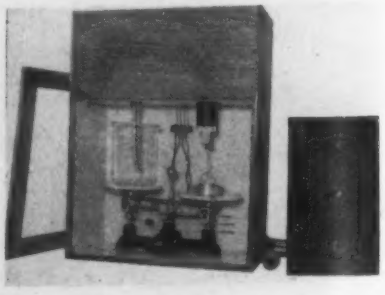
New "Type V-20 Variac" is capable of handling 20 amperes in the 115-volt model. Like previously-announced

"V-5" and "V-10" (*Instruments*, Aug. 1946, page 482; Oct. 1946, page 616) it delivers considerably more kva. per pound than older models. 115-volt "Type V-20M" is rated at 3.45 kva.; 230-volt "Type V-20HM" at 2.3 kva. Output voltage is continuously adjustable from zero to 17% above input line voltage. Both models are supplied with case and terminal box cover. Terminal box is designed for use with BX or conduit. Over-all dimensions are 7⅞" × 9⅝" × 5½"; net weight, 22¾ lbs. — *General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

Please mention number 368 when filling out card

Precision Gravimetric Flowmeter

New "Erdco Automatic Liquid Balance," originally designed for measuring flow-rate of fuel to internal-combustion engines, is announced as "a necessity for the primary calibration of continuous-reading liquid flowme-



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SAVE TIME AND MONEY!

By using PYRO, a self-contained, DIRECT READING, sturdy unit made to stand rough use. It is absolutely accurate and dependable, and quickly pays for itself.

Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest stream; no correction charts, no accessories, no maintenance expense. Special "FOUNDRY TYPE" and "Universal TRIPLE RANGE" have, in addition to standard calibrated range, a red correction scale determining TRUE SPOUT and POURING TEMPERATURES of molten iron and steel when measured in the open.

Stock ranges 1400° F. to 6000° F.

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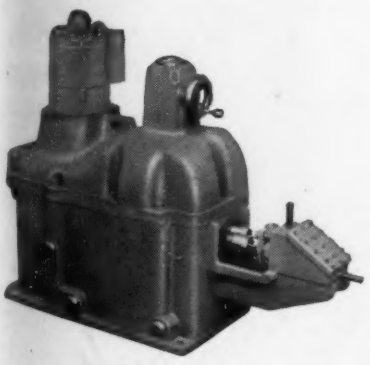
ters." Operating principle is the complete automatization of the method of measuring the time required for a given quantity of liquid to flow (a sequence of operations now performed manually in laboratories) with added advantage of minimizing fire hazard and eliminating human errors. Standard model (illustrated) has max. capacity of 1 lb./min.; 4 lbs. of chromium-plated weights with sensitivity of 0.003 oz.; valves operable at pressures to 100 lbs./in.^{2}; operates on 110-volt, 60-cycle supply. Other models may be built in any desired sizes, for corrosive liquids, etc. Balance unit and "control box" (shown next to each other in illustration) may be at any distance; or may be housed in one case.—*Engineering Research & Development Co., Box 166, Hinsdale, Illinois.*

Please mention number 369 when filling out card

Metering Pump

New "Constametric" chemical pump is a piston type pump developed especially to handle liquids in precisely con-

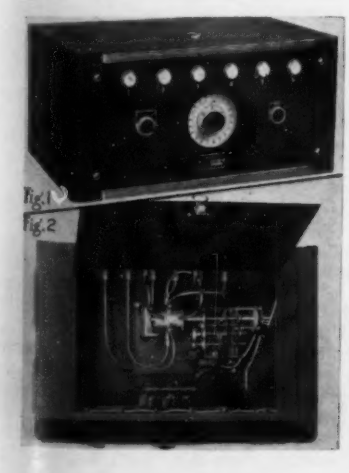


trolled volume, to deliver at a constant rate of flow (without pulsation), and to pump in minute quantities—as little as 75 ml. per hour as a maximum for an individual pump.—*Milton Roy Co., 1309 Mermaid Ave., Philadelphia 18, Pa.*

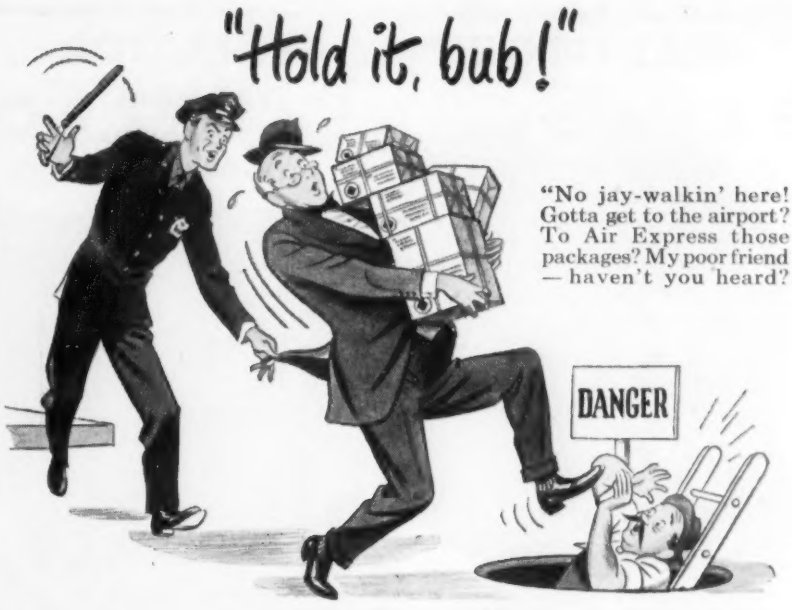
Please mention number 370 when filling out card

Atmosphere Selector

New "Selector for Atmosphere Gases" greatly increases effectiveness of maker's "Dew Point Recorder" (*Instruments*, Aug. 1947, page 731) by enabling it to analyze consecutively atmospheres from as many as six dif-



"Hold it, bub!"



"No jay-walkin' here! Gotta get to the airport? To Air Express those packages? My poor friend — haven't you heard?

"Air Express picks up those packages right at your door here, and delivers *at no extra cost*. There's no waiting around, because Air Express goes on every flight of the Scheduled Airlines. No U.S. point is more than hours away!

"And rates are low. Don't interrupt me—I said *low*. Why else do business men use Air Express to ship finished items, replacement parts and perishables *regularly*?"

Specify Air Express-World's Fastest Shipping Service

- Low rates—special pick-up and delivery in principal U.S. towns and cities at no extra cost.
- Moves on all flights of all Scheduled Airlines.
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True case history: Machine parts made in Camden were needed in Chicago in a rush. 32-lb. package picked up the 28th at 10 A. M., delivered same day at 5 P. M. 669 miles, Air Express charge only $6.88. Gave days more time to complete the job. Other weights, any distance, similarly inexpensive and *fast*. Just phone your local Air Express Division, Railway Express Agency, for fast shipping action.

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AIR EXPRESS — GETS THERE FIRST

Rates include pick-up and delivery door to door in all principal towns and cities

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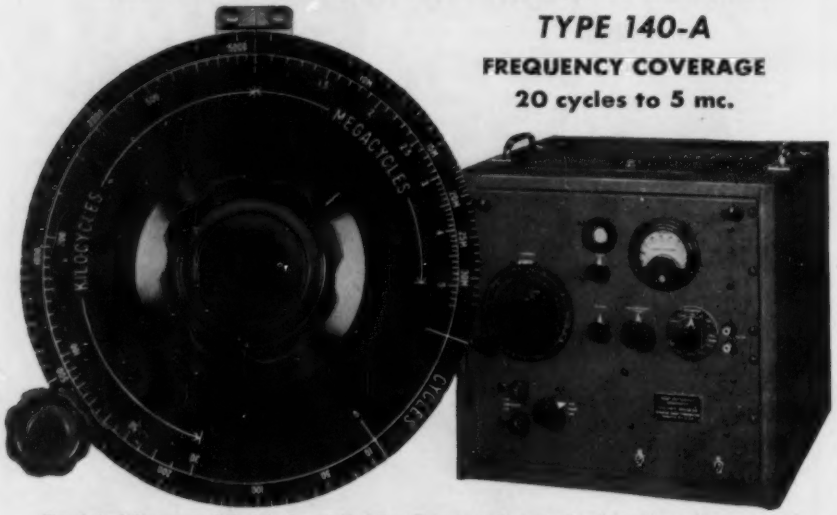
BEAT FREQUENCY GENERATOR

TYPE 140-A

FREQUENCY COVERAGE

20 cycles to 5 mc.



The six inch frequency dial of the Type 140-A Beat Frequency Generator has been planned for maximum readability and rapid setting, with combined scale lengths of the low and high ranges exceeding 22 inches. Continuous coverage of the entire audio spectrum is possible without bothersome range switching.

Frequency Range: 20 cycles to 5 megacycles in two ranges. ***Low Range:*** 20 to 30,000 cycles. ***High Range:*** 30 kc to 5 megacycles. ***Frequency Calibration:*** Accuracy ±2 cycles up to 100 cycles, ±2% above 100 cycles. ***Adjustment:*** High and low ranges have individual zero beat adjustments. Low range may be checked against power line frequency with front panel 1 inch cathode ray tube. ***Output Power and Impedances:*** Rated power output: one watt, available over the low frequency range from output impedances of 20, 50, 200, 500, 1000 ohms, and over both ranges from an output impedance of 1000 ohms. ***Output Attenuator:*** Five steps: X1.0, X0.1, X.01, X.001, X.0001. Distortion: 5% or less at 1 watt output, 2% or less for ½ voltage output. ***Write for Catalog "D"***

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Bulletin 330-C

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ferent generators, furnaces, etc., in timed sequence. It comprises a six-way valve, motor electric time clock; the five lines not feeding Recorder are continuously purged. Manual transfer of inlet valve to the next station is also possible by pressing a push button. Frequency of automatic sequence is set by control dial in center of panel. An "on-off" switch is also included. Since all six lines may not be needed at first, another feature provides a means of skipping one or more lines and returning inlet valve to the initial line automatically.—*Surface Combustion Corp., 2375 Dorr Ave., Toledo 1, Ohio.*

Please mention number 371 when filling out card

Temperature Controllers

New "Infitrol" stepless-input temperature controllers designed for use with electric and gas heating units are available with or without pyrometers. "Model IF 4" weighs 5¼ lbs.; comes equipped with a pyrometer calibrated to 2000°F. "Model IF 2" is similar but minus pyrometer; weighs 3¾ lbs. All models operate on 115-volt a.c. (220-volt units on special order). With plug-in arrangements new controllers are good only for current up to 15 amperes (rated capacity of plugs). For higher currents, permanent styles with "knock-outs" are recommended. Delivery within one week after receipt of order.—*K. H. Huppert Co., 6380 Cottage Grove Ave., Chicago 37, Illinois.*

Please mention number 372 when filling out card

Telephone-servicing Tester

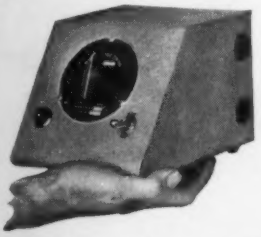
New "Type 614-A Telephone Service Meter" provides full facilities for making measurements encountered in telephone work. It is said to be the only instrument of its type that covers d-c. voltage, d-c. current, a-c. voltage, d-c. resistance, and capacitance used in telephone work. It can be used also for approximating an artificial load. Auxiliary scales provide an inductance range of 1 to 100; 1000, 10,000 henries, and an a-c. resistance range of 25-3,000,000 ohms. New simplified switching circuit uses only two switches for 25 ranges. Improved accuracy on all ranges is obtained with precision wire-wound resistors. Silver-contact switches assure minimum variation in contact resistance. A separate binding post provides direct connection to an accurate shunt for high-current range, preventing switch-resistance errors. Instrument operates from a self-contained No. 6 dry cell battery (voltage variation compensated by a d-c. resistance adjuster). For a-c. use, an a-c. line

oltage adjuster compensates against luctuations from 104 to 124 volts, 60 ycles. Case dimensions, 9⅝" × 8⅛" × 6"; net weight,12½ lbs.—*Shallcross Mfg. Co., Collingdale, Penna.*

Please mention number 373 when filling out card

Temperature Controller

New "1000 Series Temcometer" tepless temperature controller consists of only the controller portion of Series 500" temperature controller nd indicator (see *Instruments* Oct. 947, pages 932-934). Omission of pyometer and thermocouple results in an nexpensive controller for applications here indicating pyrometer is unnecssary or is already provided. "1000 eries" controller is intended for use ith electrically-heated furnaces, melting pots, etc. It regulates power input

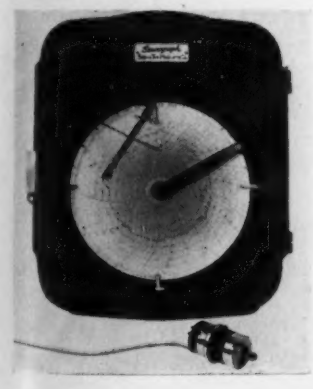


nywhere between 5% and 100% time on." Dial markings indicate percentge of watthour input of connected oad. Built into unit is a magnetic or ercury relay of ample capacity for ated load. A standard replaceable fuse rotects device from overloads. Instrument measures 6" wide, 5" high and " deep; weighs 5 lbs. Rubber feet re provided for desk use and a metal racket is also supplied for wall ounting. Eight models cover current equirements of 115 and 230 volts, 10 o 35 amperes, 25 and 50/60 cycles a.c.; nd for d.c. Various models will handle oads up to 5700 watts.—*Thermo Electric Mfg. Company, 496 W. Locust St., Dubuque, Iowa.*

Please mention number 374 when filling out card

Position Recorder

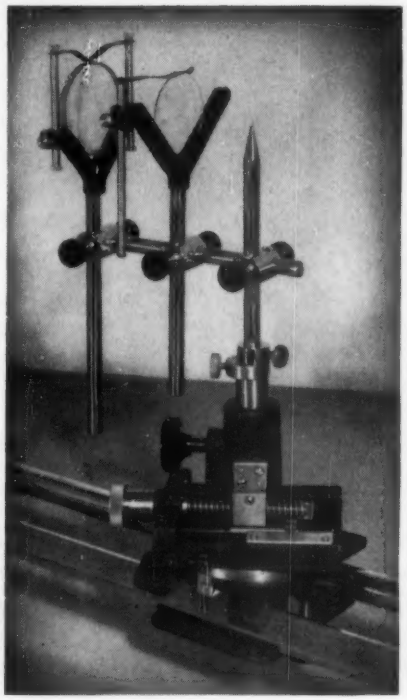
New "Servograph" is capable of recording almost any mechanical motion r position on a 10" circular chart; its nking pen driven from a remote point y self-synchronous motors. Rotation f transmitter shaft is accurately duplicated by receiver shaft with disances as great as 1000 feet separating Servograph" and transmitting synhro. Receiving synchro is connected to en through a variable-ratio mechanism said to be "the heart of the Servograph" which makes it extremely flexi-



Gaertner

OPTICAL BENCHES

AND ACCESSORIES



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Equipment suitable for any application from the simplest routine test to the most refined type of measurement.

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Field experience in maintenance of Brown, Foxboro and Bailey flow meters, temperature, pressure and liquid level recorders is essential. Knowledge of pneumatic transmission, air operator controllers and Leeds & Northrup potentiometers is desirable. Permanent openings anticipated.

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MODEL 62

SPECIFICATIONS:

RANGE: Push button selection of five ranges—1, 3, 10, 30 and 100 volts a.c. or d.c.

ACCURACY: 2% of full scale. Useable from 50 cycles to 150 megacycles.

INDICATION: Linear for d.c. and calibrated to indicate r.m.s. values of a sine-wave or 71% of the peak value of a complex wave on a.c.

POWER SUPPLY: 115 volts, 40-60 cycles—no batteries.

DIMENSIONS: 4¾" wide, 6" high, and 8½" deep.

WEIGHT: Approximately six pounds. *Immediate Delivery*

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Vacuum Tube Voltmeters
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QUICK COUPLING TYPE

A rapid and efficient means for disconnecting those thermocouple circuits that must be broken frequently.

Our Jacks and Plugs are designed for multiple mountings. These 2PS Plugs and JMSS Jacks are frequently used for pilot or experimental work. Ideal when thermocouples from a large bank must be selected for checking or recording on a multi-record pyrometer.

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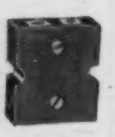

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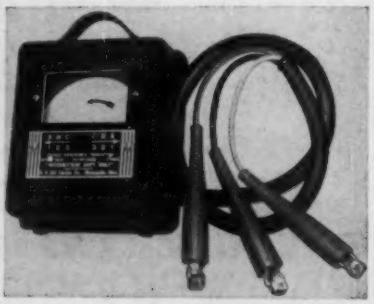

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50 to 600 volt, 25 to 400 cycles, 2, 3, or 6 phase
Model 32B . . . $52.00 F.O.B. MPLS.

- The SELCO Indicator gives you quick positive readings. Avoids costly mistakes.
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ble: pen will move full chart range with any desired motion of the synchros within a range of one-half revolution up to and including ten revolutions. Variables which can be converted to rotation of transmitter shaft include pressure, temperature, flow and most mechanical movements. Accuracy is better than 1% for 360° transmitter rotation; higher accuracy for higher ratios. Torque is less than 0.2 oz.-in. at transmitting synchro. Mechanical clock drives and synchronous 115-volt 60-cycle electric drives are available for chart speeds of 12 hours, 24 hours or 7 days. Two-pen recorders can be supplied. Immediate deliveries.—*Servo-Tek Products Co., 247 Crooks Avenue, Clifton, N. J.*

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R-f. Plate Chokes

Six new radio-frequency chokes are announced, for bands from 7 to 520 Mc. Two units are rated at 600 ma.; other four are rated at 1000 ma. New chokes are single-layer wound on low-power-factor steatite or molded plastic cores; moisture-proof coating protects the wire and holds each turn in place.—*Ohmite Mfg. Co., 4954 Flournoy Street, Chicago, Ill.*

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Gaging Comparator

New "Model 108" Comparator provides for five interchangeable tables and use of standard indicators. This quality comparator is therefore suited to a wide range of production and inspection measuring jobs. When equipped with "Micronar Indicator," it affords a means of checking plug gages. Any AGD dial indicator of #2 or #3 size having standard lug type back can be used. Pressure of contact point on workpiece can be regulated. A reed mechanism prevents side thrust from reaching indicator and thus adversely affecting accuracy. Tables are availa-

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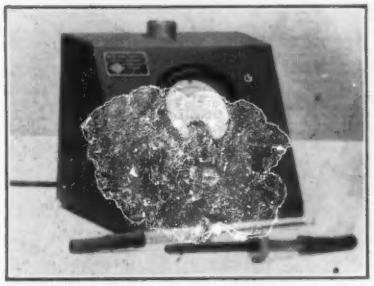

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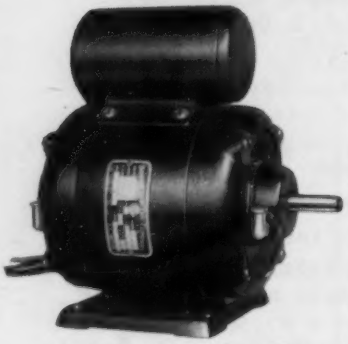

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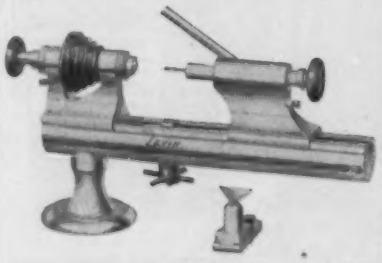

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TRIPLE RANGE CENTRIFUGAL
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Many standard ranges reading RPM, FPM, YPM, etc.
Bulletins 795-N, 796-N 797-N

HERMAN H. STICHT CO., INC.
27 PARK PLACE NEW YORK, N. Y.

ble as follows: 1½" × 4" serrated, 6" × 4" serrated, 1½" × 4" plain, and one with 1½" diameter for checking lobal conditions.—*Standard Gage Company, Poughkeepsie, N. Y.*

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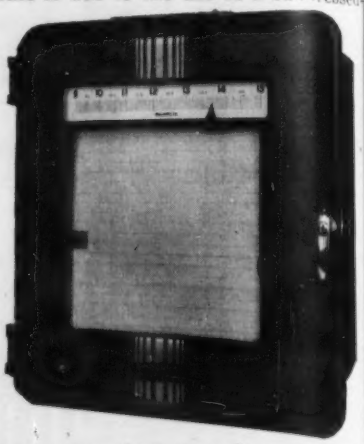
Voltage Recorders

New suppressed-range multiple-point a-c. remote-indicating voltage recorders provide highly legible recording of as many as 16 a-c. voltages on a wide strip chart. Unusual readability of scale is due to the use of a suppressed-



zero range, which spreads across entire chart width the few volts (or kv.) which operator needs to watch. Depending on speed of fluctuation in measure voltage, instrument can be either a "Micromax" or a "Speedomax"—the latter used where top speed and sensitivity are required. Either instrument can be a single-point or a multiple-point recorder. New a-c. voltage recorders are basically d-c. potentiometer instruments, and use a thermal converter as the metering element. As in all null-balance instruments, there is no line drop between recorder and metering element—hence no loss in accuracy when recorder is located at a distance from point of voltage detection. Standard ranges cover usual bus, transmission and distribution voltages. —*Leeds & Northrup Co., 4934 Stenton Avenue, Philadelphia 44, Pa.*

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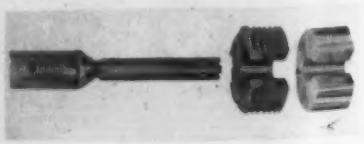
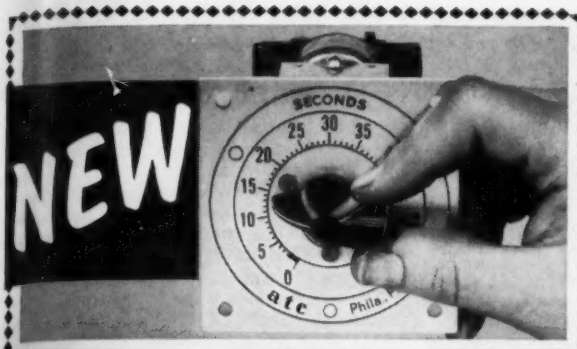
Small-flow High-pressure Control Valve

New "Microflo Control Valve with Spline Plug" claimed to be "the most important advance in valve design in the past twenty-five years," can handle flows in cc's with pressure drops in thousands of pounds. Basic element of valve is a solid Stellite valve plug which is a honed fit in a solid Stellite seat. It is said that clearances between plug and seat cannot be measured by ordinary methods, yet galling does not occur because of the type metal used. Flow control section of a "Spline Plug" is ¼" O.D. by 1⅝" long. It is a selective lapped fit in a ⅝" deep seat. This





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Automatically trips a heavy-duty electrical control switch after a pre-set time interval. 12 dial ranges from 0-15 sec.—to 0-24 hrs. Telechron motor-operated for absolute dependability. Special features available for most applications.

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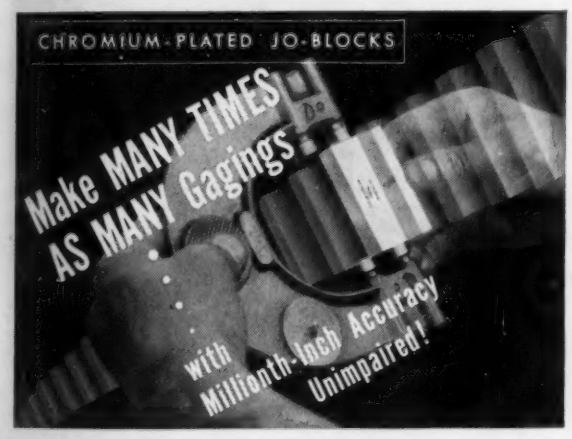

The harder your gage blocks have to work, the more you'll SAVE with chromium-plated Jo-Blocks. Wherever service is at all severe, they'll far outlast the plain steel blocks.

The resistance of chromium-plated Jo-Blocks to abrasion or impact is many times that of unprotected steel. They are also far more resistant to corrosive effects of skin acids and moisture. Being lapped and burnished to specified dimension *after* plating, their warranted accuracies are precisely the same as those of unplated Jo-Blocks.

Old sets of Jo-Blocks or gage blocks of any make, in sizes from .050" to 4.000", may be turned in to the factory for credit on new chromium-plated sets. New chromium-plated Jo-Blocks may also be had without trade-in.

The first chromium-plated gage blocks were produced by Ford Motor Company more than twenty years ago. Service records abundantly prove the vastly longer life of these fine, hard-surfaced tools. Write for literature.

CHROMIUM PLATED Ford Johansson GAGE BLOCKS

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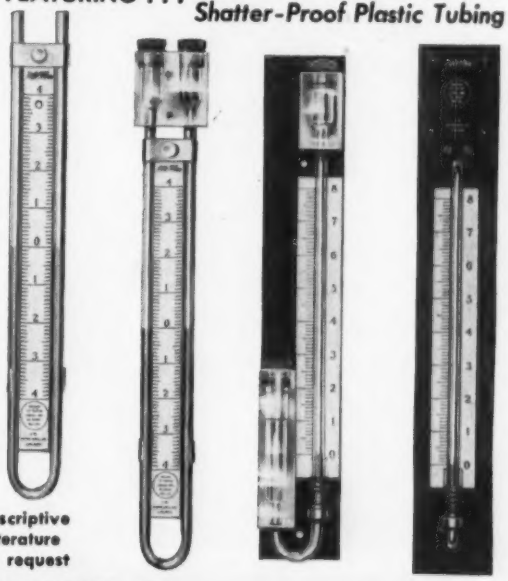
FEATURING . . . *Over Pressure Safety Trap*
Shatter-Proof Plastic Tubing



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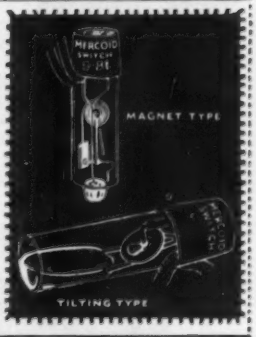
Mercury switches bearing the registered trade mark name of "Mercoid" are not subject to open arcing, oxidation, corrosion, pitting or sticking of the contacting surfaces.

There are numerous applications where these switches have a definite advantage over the open contact type switches.

Mercoid switches are available to the trade in various designs, sizes and capacities.

Our engineers gladly offer their assistance in the adaptation of our switches to your switch problems.



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Designed to automatically regulate electrically operated equipment in accordance with changes in temperature, pressure, vacuum, fluid level or mechanical movement.

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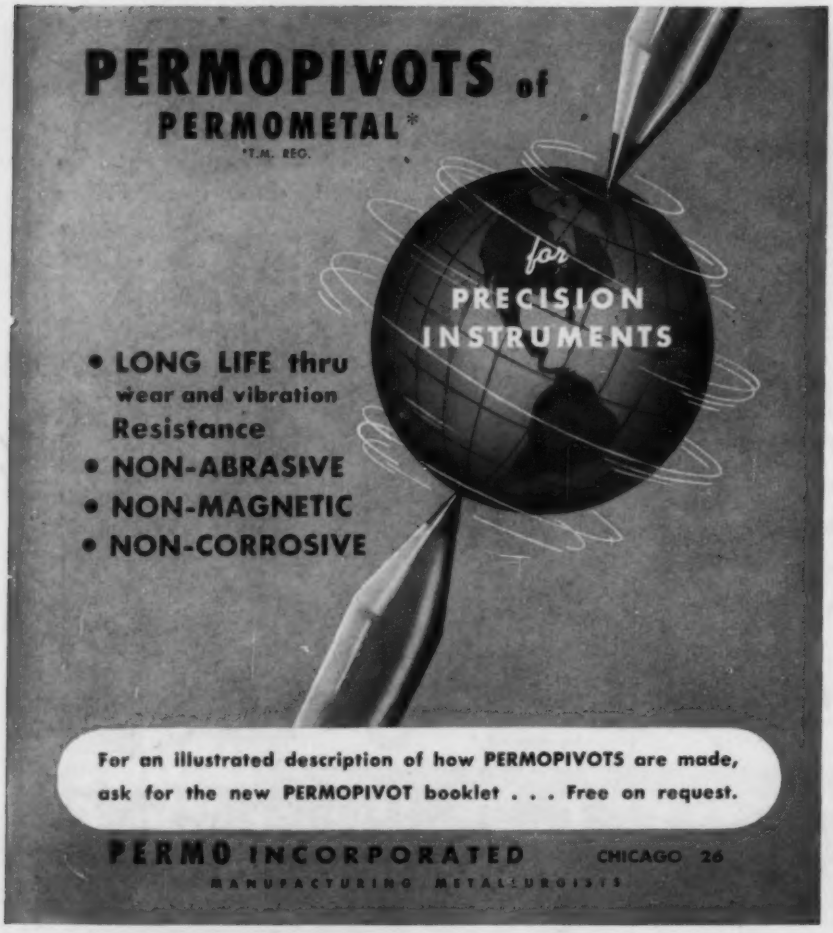

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- 6" HIGH VISIBILITY DIAL
- RANGES 0-50 INCHES OF WATER UP TO 0-200 P.S.I.
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- UNIVERSAL MOUNTING
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seat depth insures streamline or viscous flow just as plug is leaving seat. Flow control in 1" of valve travel is governed by shape of slots or grooves milled into plug surface — hence the name "Spline Plug." New valves can be provided in any body size of ½", ¾" or 1"; actual size below 3/16" normal rating. There are fifteen interchangeable valve plugs for seats numbered 1 through 15, corresponding to a valve flow coefficient of 0.63 to 0.001 (capacity of valve in gpm. of water at 1-lb. pressure drop.) Flow characteristics of #1 through #5 are equal percentage, #6 to #15 linear. Valves can be ground in for tight shut-off; have a rangeability of 50:1 or greater. When new operating conditions require a valve with different capacity, it is merely necessary to back out threaded retainer and replace plug and seat with another one of proper trim size. To illustrate the small flows which can be effectively handled, a #15 "Spline Plug" at 1/10" valve lift will pass a flow of 9cc. of water per minute at 1000-lb. pressure drop. — *Hammel-Dahl Co., 243 Richmond St., Providence 3, R. I.*

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Dew-point Apparatus

New dew-point apparatus for measuring moisture content of air and gases at approx. atmospheric pressure sells

at less than $20; consists of: (1) an outer container with inlet and outlet connections and a glass window; (2) an inner container having a highly polished outer surface visible through the window; (3) a thermometer to determine dew-point temperature, a small sample of the gas to be tested is passed through outer container while a mixture of crushed dry ice and acetone is stirred (with thermometer) in inner container. Polished surface of inner container is closely observed through glass window. At first indication of dew or moisture on polished surface, temperature is read from thermometer. Use of acetone and dry ice mixture makes possible quick checking of dew-points as low as −76°C. Device is furnished with complete directions. — *Pittsburgh Lectrodryer Corp., P. O. Box 1766 Pittsburgh 30, Pa.*

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ARE DIRECT READINGS

...THAT MINIMIZE CONVERSIONS, ERRORS, DELAYS

Put an end to the setting and reading of hairline-graduated dials on all types of machines.

Install a Veeder-Root Counting Device that will give direct and accurate *Count*rol over rate of feed, depth of cut, or any other phase of operation.

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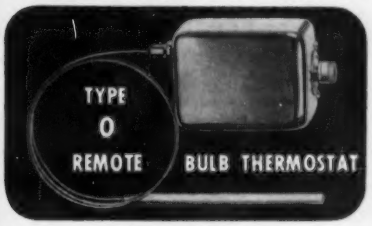

Type O Thermostats are low-cost units for industrial uses requiring accurate temperature control over narrow calibrated ranges. Widely used for liquids and gases non-injurious to brass and for metal-to-metal applications, Type O Thermostats are precise and positive throughout an unusually long life. Adjustment on some models may be by knob-pointer with calibrated dial covering any 120° to 250°F ranges from –120° to 600°F, or on other models by screw driver covering entire range from –120° to 180°F, 50° to 350°F and 50° to 600°F. Type O controls are fitted with an ambient temperature compensator. Standard models are furnished with polished chrome plated housings and may be equipped with a remote bulb best suited for your application.

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Standard & Special Thermostats & Pressure Switches

EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

**Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.*

BULLETIN No. 3 ON REQUEST
THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
NEWPORT, RHODE ISLAND, U. S. A.

STANDARD *Precision* TIMERS

The most accurate and rugged instrument for the precise measurement of time.

Model	Reads	Totalizes	Accuracy	Net Price
S-100	1/5 sec.	6000 sec.	±.02 sec.	$45.00
S-60	1/5 sec.	60 min.	±.02 sec.	$45.00
S-10	1/10 sec.	1000 sec.	±.02 sec.	$45.00
S-6	1/1000 min.	10 min.	±.02 sec.	$60.00
S-1	1/100 sec.	60 sec.	±.01 sec.	$60.00
MST	1/1000 sec.	.360 sec.	±.001 sec.	$95.00
MST-500	1/1000 sec.	30 sec.	±.001 sec.	$125.00
SM-60	1/100 min.	60 min.	±.02 sec.	$45.00

Furnished in portable cases as shown, or for panel mounting. May be equipped with electric reset. Write for Bulletin 153.

Write for information on these other STANDARD Products:

Precision Timers (many models)	Bulletin 153
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Electric and Chrono-Tachometers	Booklet 151
Electric Clock and Program Systems	Bulletin 131

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THE Standard Electric Time Co.
SPRINGFIELD 2 STANDARD FOUNDED 1906 MASSACHUSETTS

SHOP KINK

Improving Temperature Compensation of Recording Pyrometers

By PAUL LINCKE, Toledo, Ohio

ONE of the principal faults of millivoltmeter pyrometers using a bimetallic spiral to compensate for ambient temperature changes is that the compensation is accurate at only one point on the scale. If, for example, the instrument is exactly compensated at mid-scale, it is considerably overcompensated at the low end and undercompensated at the upper end. A number of millivoltmeter recorders in service in our plant were not satisfactorily compensated. It was considered desirable to improve these.

Negative temperature coefficient resistance units made by the Keystone Carbon Co., St. Marys, Pa., made it possible to do this in a highly satisfactory manner. By using only a portion of the bimetallic spiral sufficient to shift the open-circuit zero point an amount on the scale or chart equivalent to the change in ambient temperature and using a negative temperature coefficient resistance (NTC) unit to compensate at the upper end, excellent compensation is achieved over the entire range. A thermostat-controlled temperature box is necessary for testing. The approximate amount of spiral can be estimated by observing how much a rise in temperature of 50 or 60°F. changes the open-circuit pointer position and what fraction of this is represented by 50 or 60°F. on the chart or scale. The amount of NTC resistance required can be calculated, the positive temperature coefficient of the galvanometer coil needing to be compensated for and a little allowance made for reduction of the magnet's strength with increase in temperature. The required amount of resistance change can be found more practically by test, shunting the series (manganin or other negligible-temperature-coefficient resistance) coil and adjusting an external variable resistance to give a certain upper scale reading with the proper voltage applied, first with the instrument at a low temperature (just as though calibrating it) and then with the instrument at a high temperature, adjusting the resistance to give the same reading on the instrument with the correct voltage for the high ambient temperature. Knowing the difference in resistance or change in resistance required for a certain change in ambient temperature, the proper NTC resistance unit can be chosen.

For Brown 0-3000°F. recorders, one-half turn or slightly less of bimetallic spiral and a 20-ohm "Type LA" NTC unit in series work out well. Of course the series resistance coil has to be reduced an amount equal to the NTC unit.

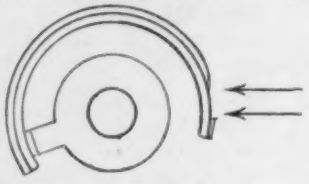

Fig. 1

More satisfactory results seem to be obtained when using only a half-turn of bimetallic spiral by extending the point of attachment of the hairspring about one-eighth turn beyond so that its motion will be more concentric. This can be done as illustrated by filing away one of the two metals of the extended portion.

The calibration records herewith (Table I), and Fig. 2, show the improvement which can be obtained by the combination of Negative Temperature Coefficient Resistance Units together with the bimetallic spiral over the conventional method of using a bimetallic spiral only. In every instance the first trial with the combination has been an improvement. However, subsequent adjustment can give still better results. Instrument No. 4, for instance, after two succeeding corrections, showed no discernible difference between the calibrations at 60° and at 120°. There is no appreciable middle temperature error.

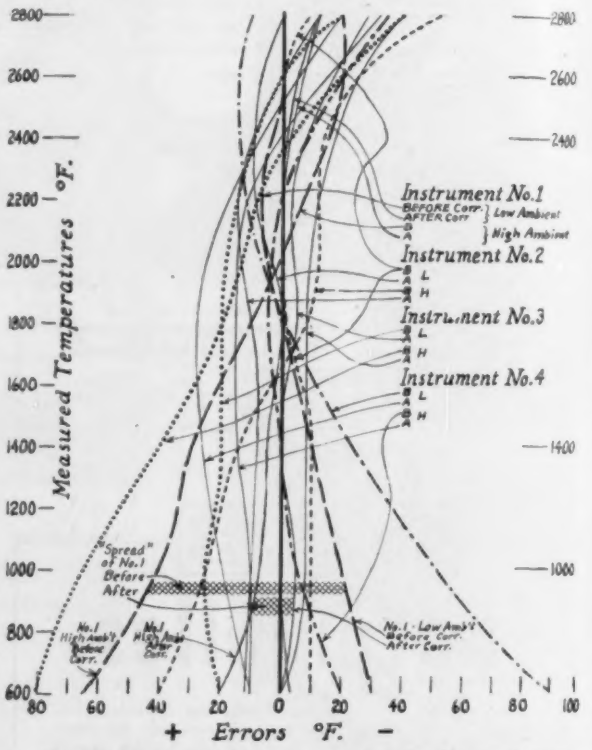

Fig. 2. Improved performance of recorders after first modification and adjustment. Subsequent adjustments gave even better results.
All broken lines—Before correction
All thin solid lines—After correction

TABLE I—CALIBRATION RECORDS

Figures in light-face type—Before correction
Figures in **bold-face type**—After correction with NTC unit

Amb't Temp.	Open circ. pos.	Calibration points and errors in °F. 600	1000	1400	1800	2200	2600	2800
		Instrument No. 1						
68	30	−30	−20	−10	0	+ 7	0	0
128	145	+65	+40	+30	+10	− 7	−20	−20
70	**80**	**0**	**− 5**	**0**	**− 3**	**0**	**− 5**	**−12**
128	**150**	**+20**	**+ 7**	**+ 5**	**0**	**0**	**− 7**	**−12**
		Instrument No. 2						
76	60	−10	−10	−10	0	0	0	− 8
124	200	+40	+25	+10	−8	−12	−25	−53
68	**58**	**− 3**	**0**	**0**	**0**	**+10**	**+ 8**	**0**
122	**132**	**+12**	**+10**	**+ 8**	**+10**	**+15**	**0**	**−10**
		Instrument No. 3						
72	120	+20	+25	+20	+20	+15	0	−15
122	225	+80	+65	+40	+20	+ 8	−20	−40
80	**90**	**0**	**0**	**0**	**− 5**	**− 3**	**−13**	**−28**
126	**120**	**0**	**− 8**	**− 8**	**− 8**	**−12**	**−25**	**−40**
		Instrument No. 4						
62	−35	−90	−50	−25	0	+12	+15	+10
120	110	−20	− 5	0	+ 5	0	−20	−35
74	**80**	**+10**	**+20**	**+26**	**+28**	**+18**	**− 5**	**−25**
120	**118**	**+10**	**+10**	**+15**	**+15**	**+10**	**−15**	**−32**

Instruments pays $5 (or more*) for each shop kink or other time-saving and accuracy-promoting idea accepted for publication. Please observe these rules:

1. Type double-spaced on one side of paper. Author's name and address at top of first page.

2. Diagrams must be in black ink (no blueprints). Lettering (if not made with aid of machine) may be soft-penciled, to be inked-in by *Instruments*.

3. Only professional-grade photos will be accepted (preferably 5 x 7 or 8 x 10 glossies).

4. Each contribution to describe ONE method or device. An author may send as many as he likes.

5. Mail all entries to Shop Kinks Dep't of *Instruments*, 1121 Wolfendale St., Pittsburgh 12, Pa.

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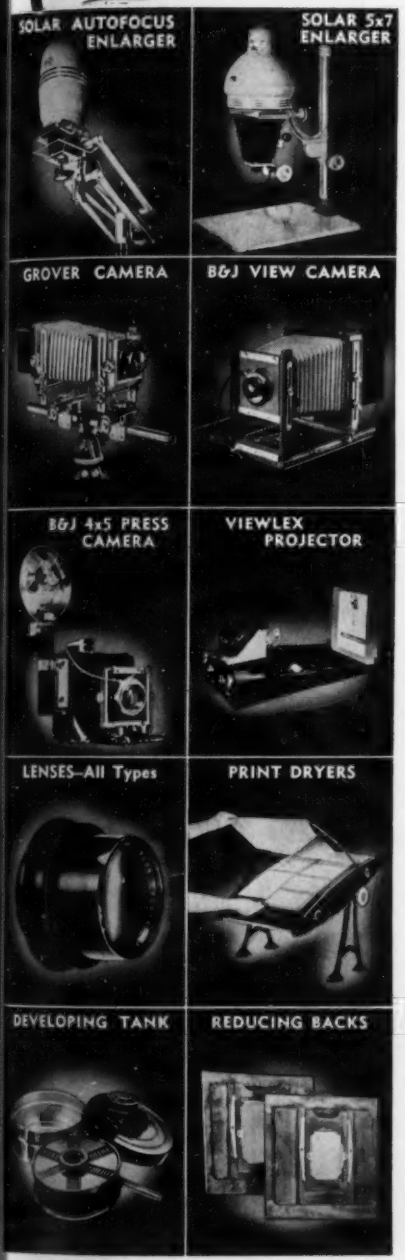

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Please read editorial explanation on page 266.

SIXTH "GALLERY"

The "Arsenal *of* Democracy" Years

1940 *and* 1941

1940. "A new worm-gear speed reducer motor, the 'N-10RG,' was added . . . has achieved popularity in the larger instruments and control devices." —W. M. Yogerst, Bodine Electric Co.

1940. "First contract for design and construction of static-dynamic measuring and recording equipment was signed with U. S. Army Air Forces."—G. E. West, Consolidated Engineering Corp.

1940. "Solid glass beads of Kimble 'N-514' glass ware announced at prices comparable to the beads formerly imported, made of glass of low resistance to chemical attack."—J. J. Moran, Kimble Glass.

1940. "Bailey 'Pyrotron' Recording Resistance Thermometer introduced. Employed electronic circuit to balance Wheatstone Bridge instead of customary galvanometer."—E. B. Bossart, Bailey Meter Co.

1940. "By utilizing the same principle as used in the textile 'Moist-o-Graph,' Brown engineers developed equipment capable of measuring continuously and recording the moisture content of a sheet of paper as it moved at a high speed through the dryer."—C. C. Roberts, Brown Instrument Co.

1940. "Spark Unit . . . offered high power in the sparking discharge and precision control of sparking through a synchronous interrupter, again providing commercial equipment which, up to that time, had to be custom built."—Gwen Barkelew, Applied Research Laboratories.

1940. "The 'rate-of-approach' feature was added to Micromax Electric Control. . . . made it possible to bring a heating process up to the control temperature rapidly—but without danger of overshooting. Now a standard part of all L&N Electric Control, . . ."—H. M. Parshall, Leeds & Northrup Co.

1940. "A complete line of standard Constant Voltage Transformers was made available in capacities up to 10 kva. and the use of the transformer expanded . . . wherever electrical or electronic equipment is required to carry out or supervise a precise operation."—C. H. Humes, Sola Electric Co.

1940. "Bell Telephone Laboratories developed and Western Electric manufactured the Western Electric Gun Director which provided the foremost factor in preventing Germany from annihilating London during the air raids and use of the robot bomb in 1944."—F. H. Lovette, Historian, Western Electric Co.

1940. "American introduced the Carbo Controller . . . combined temperature and pressure control device for soft drink carbonators. It resets the pressure in accordance with the temperature of the liquid, thus providing a constant gas volume in the drink being bottled, . . ."—S. Goodwin, Manning, Maxwell & Moore.

1940. "The 'Mercury' Electric Counters were the first small, compact, dependable electric counters. Features included: Small, compact design; accurate, dependable operation at speeds up to 600 counts per minute; small current requirement; tamperproof construction; and low cost."—R. H. Allbright, for Production Instrument Corp.

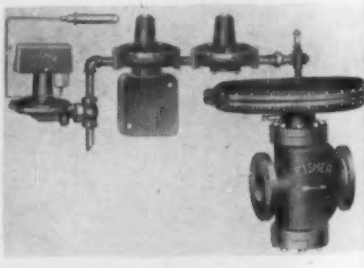
1940. "The Micro-Hardness Tester was produced by Eberbach for testing grain hardness of alloys by means of a Vickers type diamond indenter. The size of the microscopic indentions are measured, and these measurements may be formulated with the amount of the micro load to provide standard hardness numbers."—L. W. Bittman, Eberbach & Son Co.

1940. "DuMont introduced the 'Type 208' Cathode-ray Oscillograph. . . . has come to be recognized as the standard oscillograph, the basis of comparison for all other oscillographs. 'Type 208' was a general-purpose oscillograph combining the most desirable features for the widest range of applications. . . ."—J. H. Ruiter, Allen B. DuMont Laboratories.

1940. "Long-scale Switchboard Indicating Instruments . . . proved ideal for switchboards on warships . . . Case size was only 4½" square, yet scale length was 7". As compared with a standard instrument, it had 36% more scale length yet it took up only 20% of the space. Immediately, the Navy commandeered all production, and that situation held through the war. . . . Twelve different types: [to electrical], thermometers and tachometers —R. Faille, Apparatus Dep't, General Electric Co.

1940. "Wood's Replica Gratings and Spectrometer. The ruling from which the replicas are made is an 'echelette' ruling and results in concentrating 40% to 60% of available light into one spectrum—the first order on one side."—E. E. Brown, W. M. Welch Mfg. Co.

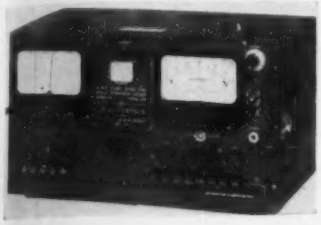
1940. "New and greatly improved designs of Kipp Gas Generators were announced. (Previously the body and funnel for this item were formed off-hand . . . No two articles were alike. . . . if a piece was damaged, the whole assembly became useless. Because of the length of time needed to shape the parts, a certain type glass was needed, and it had little resistance to heat shock.) For the new design, molds were provided, all grindings were interchangeable and a borosilicate glass was used."—J. J. Moran, Kimble Glass.



1940. "Fisher Time-Temperature Gas Pressure Booster . . . to control reduced and to automatically adjust that pressure in accordance with atmospheric temperature changes."—J. J. Muller, Fisher Governor Co.

1940. "Esterline-Angus developed its supersensitive direct-writing recorder with a range of 0-1 milliampere d.c. . . . ruggedness, accuracy and versati-

. . . use with amplifiers to record nd, light, color, vibration and mi- te displacements. Another improve- nt in 1940 was the addition of ad- stable magnetic damping to all elec- dynamometer measuring elements. . ."—Don Brewer, Esterline-Angus

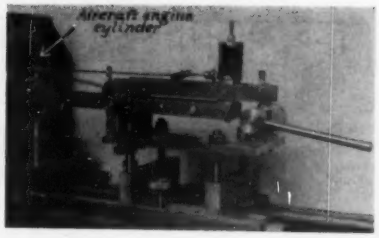


940. ". . . introduced 'Model 58 UHF dio Noise & Field Strength Meter' . many new features of design . . . ge of 15 Mc. to 150 Mc., filling a g-wanted need . . . Also in 1940, the t commercially-built Pulse Genera- . . . important for radar . . ."— M. Weed, Measurements Corp.

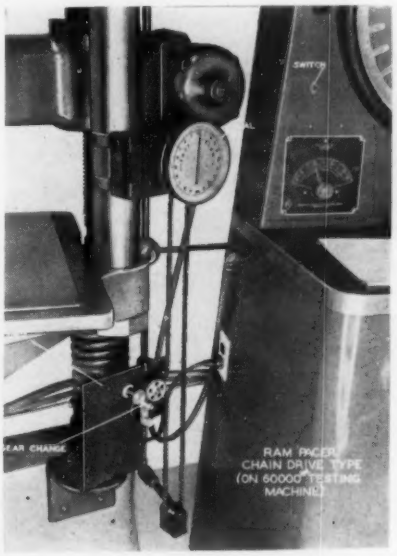
940. "Chronoscope (Remington Arms .) . . . required a special ballistic pe indicating instrument made by s company, and we were given the ntract to build the entire instrument. veral different types were made, . . . re one of the standard means for ting bullet velocities during the war. Pressure Indicator was developed to asure peak gun barrel pressures."— J. Lush, President, Rawson Elec- ical Instrument Co.

940. "Potentiometer-type Optical Py- meter developed. Employing the basi- ly accurate 'disappearing-filament' thod of measurement, it made it pos- le for the operator to read tempera- es directly, without any need for con- ting calibration curves or charts. At same time, the complete instrument s made more compact and consider- ly easier to operate."—H. M. Parshall, eds & Northrup Co.

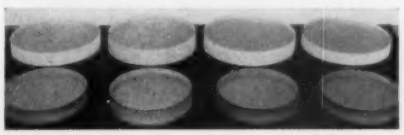
940. "When the new '3-a' fittings re adopted by the dairy industry, it s found that the large 13-H hex. t would have to be attached by slip- ng the nut over the thermometer case veloped a patented idea of using a d causing possible damage to the lished surface of the case. Palmer ecial nut so that it could be slipped er the stem section of the thermom- r and then fastened into place."— E. Honningford, Palmer Thermom- ers Inc.



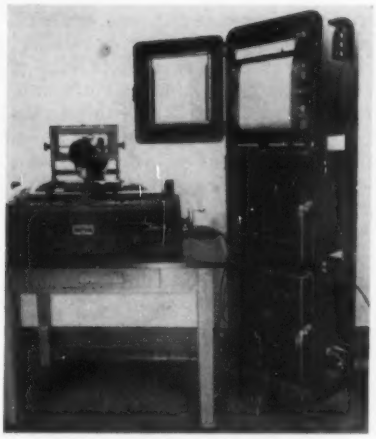
1940. The McKee Wear Gage. "Apparatus developed at the NBS utilizing a diamond indentation method of measuring extremely small increments of wear—as little as ±0.00004". The indentation is of such shape that a relatively small amount of wear will make a definite change in one or more measurable dimensions of the mark. (Photo shows original gage; a commercial form is made by the American Instrument Co.)" —Hugh Odishaw, National Bureau of Standards.



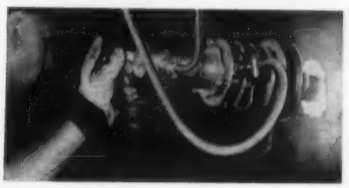
1940. "Head motion speed control in Baldwin testing machines . . . made possible constant ram speed. . . ."—M. G. Van Voorhis, for Baldwin Locomotive Works.



1940. The Standard Optical True Planes. "The Standard True Planes of the United States, produced at the NBS, are disks of fused quartz which has been carefully annealed and then optically polished using rouge as the abrasive. Illustrated are four 9" in diameter and 1.5" thick and four 11.5" × 1.5". Because the thermal expansivity of fused quartz is only 0.0000004 per deg. C. (about one-thirtieth that of steel) they are not distorted by temperature changes during polishing. . . . It was therefore possible to polish them plane and measure any errors in the planeness (by interference of light-waves) with an accuracy of two ten-millionths of an inch. . . . equivalent to an accuracy of one part in fifty million across the surface of each Plane. . . . used at the Bureau to test and calibrate working standards of industry, which in turn are used to test . . . prisms, surface plates, precision gages, etc."—Hugh Odishaw, National Bureau of Standards.



1940. "The Knoor-Albers Microphotometer, developed by L&N in 1940, was, to our knowledge, the first commercial recording microphotometer. Originally designed as a research laboratory instrument, this equipment has found considerable use in industrial process control. . . ."—H. M. Parshall, Leeds & Northrup Co.

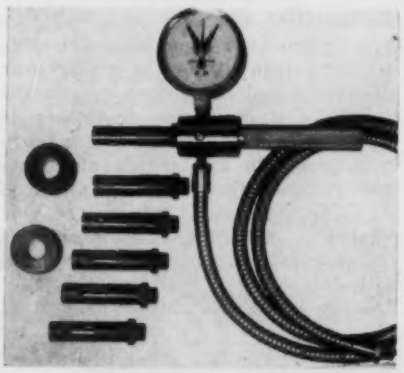


"1940 found Brown producing the 'Radiamatic,' the first total radiation type pyrometer compensated for ambient temperatures, . . . a temperature measuring and controlling system that would function where thermocouples could not and eliminate the errors caused by changes in ambient temperatures. Applications: where vibration and shock break thermocouples, where the work rotates . . . accuracy, speed, sensitivity, and ruggedness never before attained with this type of instrument."—C. C. Roberts, Brown Instrument Co.

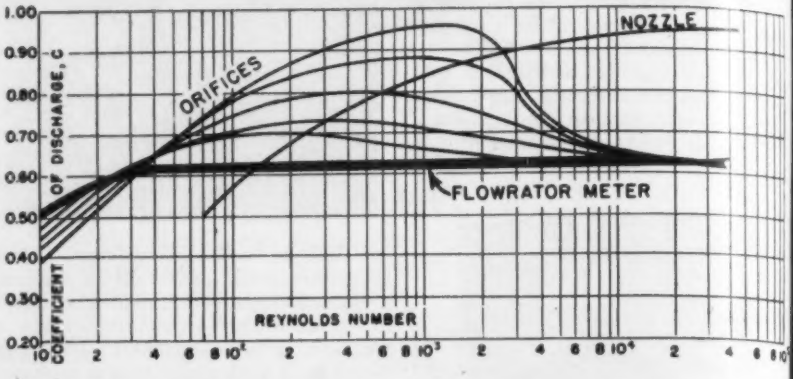
1940. "The 'Solu-bridge.' . . . No better example of erstwhile laboratory procedure reduced to overalls for workaday applications . . . compact instrument adapted for direct measurement of the concentration of solutions of many different types. . . . the simplest, most economical type of conductivity tester . . . for the first time a foolproof bridge type conductivity apparatus selling under $50. Since its introduction,

over fifty specific-purpose models . . . Industry after industry has been able to put conductivity control into plant operation. The experience obtained in using the inexpensive equipment has led to more and more use of recorders and completely automatic controls. . . ." —A. C. Lescaboura, for Industrial Instruments, Inc.

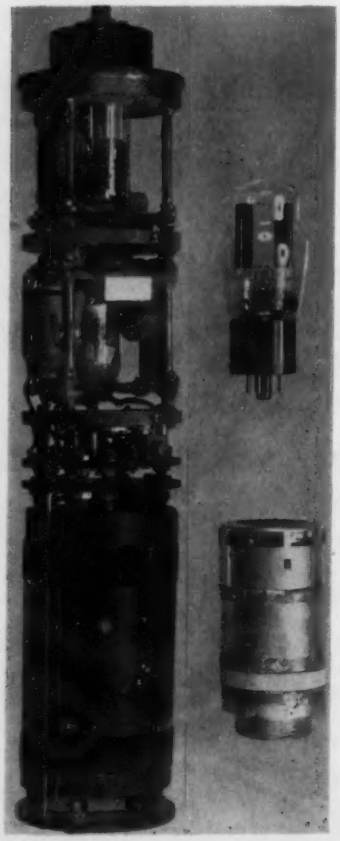
1940. "The 'Model 2221 Autoflight Direction Indicator' was first manufactured for the Army Air Corps . . . described as the 'B-20 Compass' in service manuals. . . . During the war years the Company developed a complete line of military compasses, repeater systems, remote compasses . . ."—Peyton Carroll, Autoflight Instruments.



1940. "Pneumatic Comparator Gages . . . recognized by manufacturers of high-precision parts, . . . for use in quality-control systems. Illustration shows six interchangeable pneumatic plugs for measuring holes of 0.940" to 0.960", each to a tolerance of plus 0 minus 0.0005". Two master rings for setting the equipment are shown also. The equipment illustrated was delivered in 1940 to a rayon manufacturer who is still using it . . . This Air Gage used a high-pressure system which obviated the need for cleaning the surface before measurement; was mounted on a flexible hose, so that measurement could be made while the work was in the boring machine; and had nozzles which were recessed below the surface of the pneumatic plug. The plug design was an innovation, in that the outside diameter of each plug was made smaller than the work to be measured, and the plug served merely to position the work in respect to the nozzles which performed the actual measurement. The Bourdon-tube indicator showed the true diameter of the hole being measured. Essentially, the construction of all air-gaging plugs has followed this basic design."—C. H. Thompson, Moore Products Co.

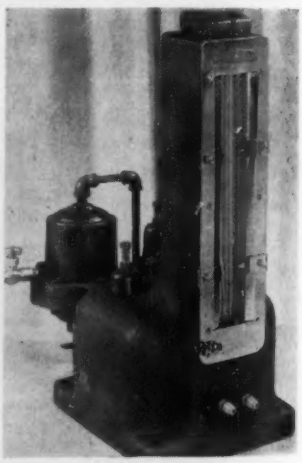


1940. "First viscosity-immuned flow-rate metering instruments developed: by extending Reynolds number range over which constant discharge coefficient is obtained from approx. 10,000 (as in orifice type flowmeters) down to as low as 80 with umbrella-shape float in variable-area meter."—Kermit Fischer, Fischer & Porter Co.



1940. "The first successful radio proximity fuze in the world, constructed by the NBS and tested by Bureau scientists less than two months after initiation of the program. The dimensions of this fuze, excluding the whip antenna and battery (not shown) were 14" in length and 3¼" in diameter. In contrast, the later generator-powered proximity fuze (right) for mortars measures only 4¾" in length with an overall diameter of 2". Note conventional radio tube for size comparison."—Hugh Odishaw, National Bureau of Standards.

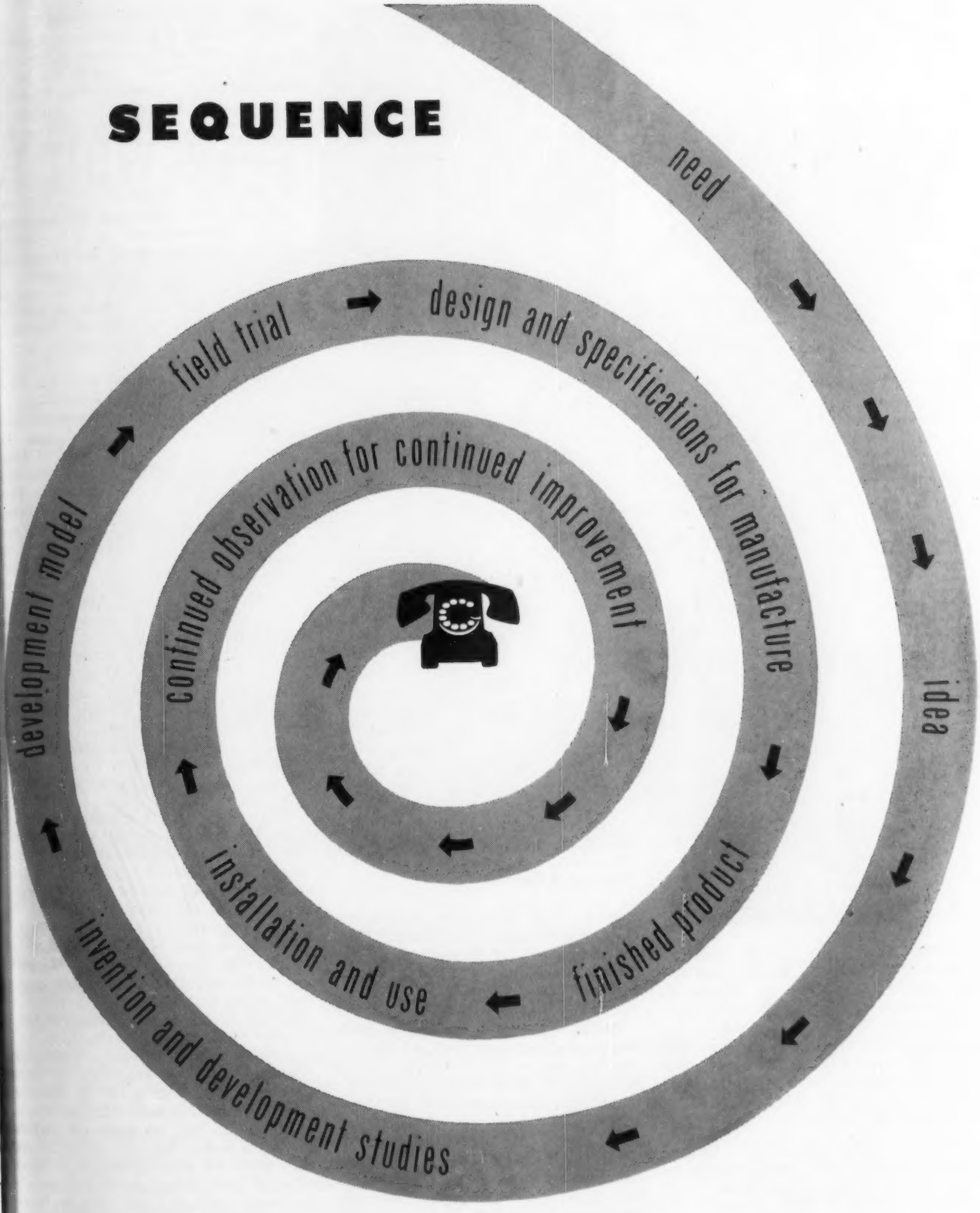
1940. "The 'Type B' and 'Type C' Thermostats were developed. . . . the first of their type . . . several features not possible in previous controls whose adjustment was through a knob and mechanical gear set-up. A wider rang (50°F. to 600°F.) could be covere with positive assurance of accurat settings . . . because of the specia micrometer providing settings to frac tions of degrees, plus effective ambi ent-temperature compensation whic permitted the use of wide-range liquid filled bellows. . . . fast response an absolutely uniform bellows motion, po degree, over a wide range of tempera ture changes."—E. C. Clark, Jr., fo United Electric Controls Co.



1940. "The Sheffield 'Precisionaire' flow type air gage for rapid measuring of ID, bell-mouth, out-of-round an average diameter, as well as OD. . . . Instrument shown here was the firs one of its kind . . . used for many years by Pontiac Div. of General Motors . . now in Smithsonian Institution."—C. W. Hamilton, Sheffield Corp.

1940. "Dependent upon the mecha nism of the pneumatic force-balance, tw important refinements of hydraulic ma chine operation were incorporated: (1) the 'Head Position Maintainer' which holds the head movement within 0.0002"; (2) the 'Load Maintainer' which holds loads within two dial divisions . . . outstanding advances: (1) 66" long by dicating dial; (2) several load ranges o one dial; (3) ability to change ranges dur ing test; (4) increase in already high sensi tivity; (5) tremendous spread of available ranges—as low as 0.005 of machine capa

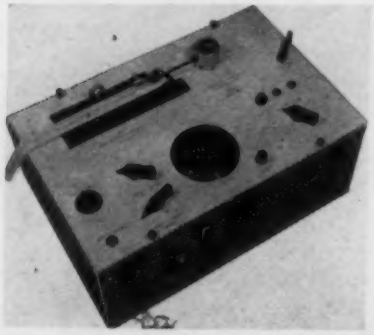
SEQUENCE



At Bell Telephone Laboratories, more than 2300 scientists, engineers, and their associates are continually exploring and inventing, devising and perfecting for improvements and economies in telephone service.

BELL TELEPHONE LABORATORIES

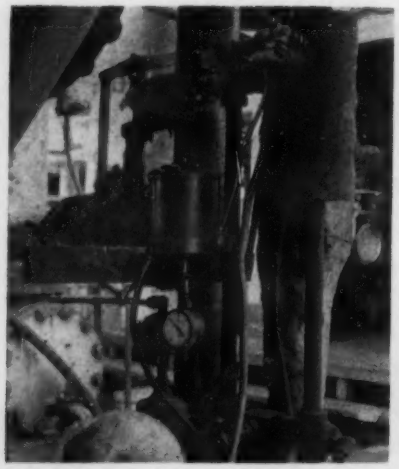
ity; (6) ability to drive recorder without sacrificing accuracy or sensitivity; (7) ranges capable of withstanding great overloads without damage—some as great as 2500%. . . ."—M. G. Van Voorhis, for Baldwin Locomotive Works.



1940. "The electroencephalograph was redesigned . . . Although frequencies to be amplified lay close to those of the power line, so that the patient picked up large interfering voltages . . . it was found possible to balance and filter out such interference so that instrument could be used in any location and without shielding the patient. . . . Battery operation was eliminated. . . . During this year also a new oscillograph was invented to employ electrically-sensitive recording paper produced by the Western Union Co. . . . required no maintenance as did ink-writing pens. The apparatus was reduced to a very small size and furnished in a single portable case."—Lovett Garceau, Electro-Medical Laboratory, Inc.

1940. Accelerated Aging Lamp for Plastics. "Equipment designed and constructed at the NBS for accelerated weathering (sunlamp-fog) and color-fastness to light tests of plastics. The plastic specimens are mounted on a disk which is rotated in order to expose the specimen uniformly to the ultraviolet light. . . . "—Hugh Odishaw, National Bureau of Standards.

1940. "A pneumatic null balance method for measuring process variables was first developed by the Moore Products Co. early in 1940. (Today, this basic system is used for temperature, flow, [etc. where] variable can be converted to a range of pressures; and for complete process control with reset, throttling, and derivative functions.) Illustration shows one of the first (1940) Differential Pressure Transmitters, still in use by a Philadelphia refinery on an interface level application. . . . Interface between furnace oil, and water which contains a trace of caustic. Owing to the small difference in gravities, conventional manometer-type equipment previously



had proved unsatisfactory. Furthermore, seals were needed and the emulsification of the sealing liquid had produced variations in the differential pressure. The Moore Differential Pressure Transmitter overcame these difficulties . . . amplified the differential and transmitted the measurement to an indicating controller. With the pneumatic null balance system, the seals remained in practically a static condition and emulsification was virtually eliminated. The calibration, once established, remained constant. (Subsequent models of this instrument have been made of corrosion-resistant materials so that, in many cases, the necessity of seals was eliminated.)"—C. H. Thompson, Moore Products Co.

1941. "The first deadbeat gyro compass . . . the Mark XI-Mod 6 Gyro Compass."—C. H. Jones, Sperry Gyroscope Co.

1941. "Further improvements in Projection Comparator Densitometer."—Gwen Barkelew, Applied Research Laboratories.

1941. "Ashcroft introduced silver brazed joints for safety on bronze Bourdon tubes."—S. Goodwin, Manning, Maxwell & Moore.

1941. "Bell Telephone Laboratories engineers developed the 'Fastax' 16mm. camera capable of photographing 4,000 frames per second."—F. H. Lovette, Historian, Western Electric Co.

1941. "Apparatus of Kimble Amber Resistant glass was introduced. This was the first apparatus advertised that cut off light completely in the lower part of the visible spectrum."—J. J. Moran, Kimble Glass.

1941. "Consolidated Engineering Corp. took over the entire Sperry-M.I.T. line of vibration and strain measuring equipment formerly built by the Sperry Gyroscope Co."—G. E. West, Consolidated Engineering Corp.

1941. "Hook-on Volt-ammeter. . . . a means of easily measuring both alternating current and voltage. Hooked around the line, the instrument reads amperes; with leads connected to its binding posts, it reads volts . . ."—R. Faille, Apparatus Dep't, General Electric Co.

1941. ". . . developed 'Model 75,' the first standard signal generator to cover the i-f. and carrier ranges of high-frequency receivers . . . 50 to 400 Mc. in one range . . . output was from 0.2 microvolt to 0.2 volt . . . modulation continuously variable to 50% at 400 and 1000 cycles."—E. M. Weed, Measurements Corp.

1941. ". . . affiliation of A. R. L. and Dietert, and marketing of equipment under the trade name A. R. L.-Dietert. In May of this year, A.R.L. purchased the Dietert spectrometric interests . . . each company was able to increase its specialization . . . A.R.L. in spectrometric equipment."—Gwen Barkelew, Applied Research Laboratories.

1941. "DuMont introduced the 'Type 215' Linear Time-Base Generator . . . used to extend the low-frequency time base of any 5" balanced-deflection DuMont oscillograph. . . . was of great value for studying continuous low-frequency phenomena or transients. Provision was made to initiate the sweep either manually or by the external signal itself."—J. H. Ruiter, Allen B. DuMont Laboratories.

1941. "Electronic Alarm System, 'Type BL-300' . . . capacitance type alarm system . . . the first of its type which would operate satisfactorily in the field through rain, fog, snow, hail, etc. . . . large research organizations had intimated that it was impossible . . . widely used before, during, and after the war to protect property from intruders and saboteurs . . ."—G. H. Browning, Browning Laboratories.

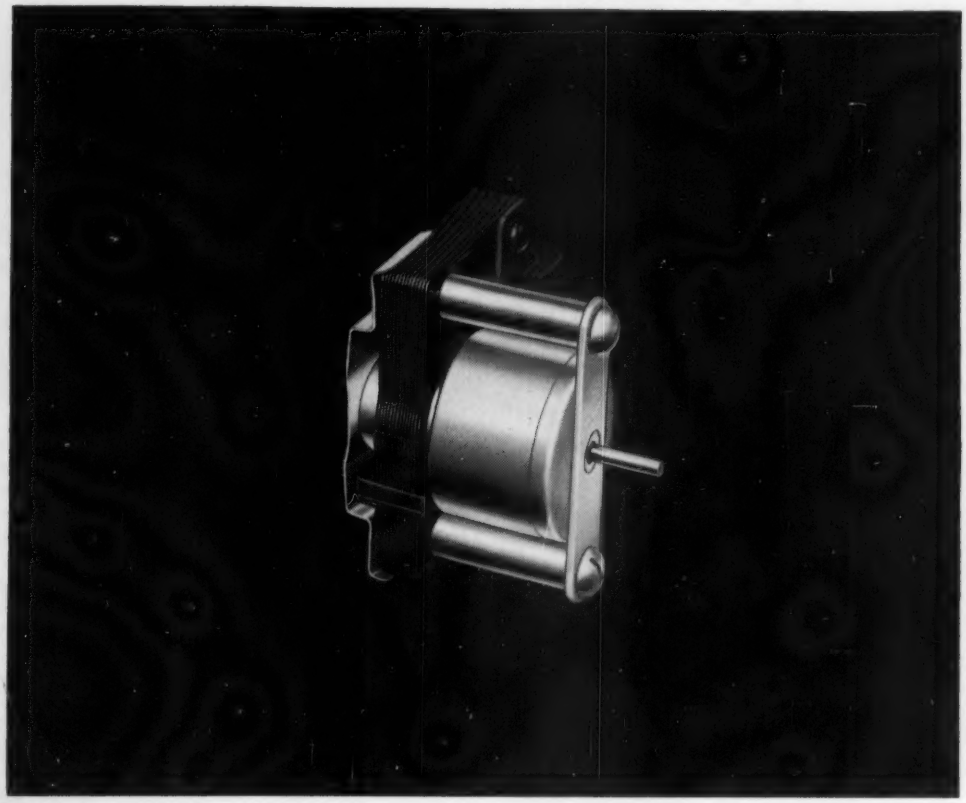
1941. "High-vacuum evaporator . . . for use in coating optical surfaces with low-reflection coatings (licensee under the original M.I.T. patents). Rapid production and sale of these units led to greatly increased production of coated optics. . . . Similar but larger units have since been developed which enable continuous applications of metals to cloth, cellophane, capacitor paper, and other materials at high speed."—Stanley Heck, National Research Corp.

1941. "The DuMont 'Type 233' Cathode-ray Oscillograph was produced . . . a large-screen unit of moderate cost, suitable for use in lecture demonstrations as well as laboratory studies in which a detailed analysis of the fine structure of wave-forms is required. The 20" c-r. tube provided a trace of sufficient intensity and size to be observed with ease at distances normally encountered in . . . auditoriums."—J. H. Ruiter, Allen B. DuMont Laboratories.

1941. "Portable Watthour-meter Standard. . . . combined, for the first time, a capacity essential to the testing of both low- and high-current-rated meters with the light weight and small size of the best low-capacity standards. Wide operating range and excellent testing flexibility were obtained by the use

For a host of domestic and industrial applications

A new ½ rpm motor by *Telechron*



HERE'S a brand-new Telechron synchronous electric motor that will find many important uses—an accurate, long-life motor with a terminal-shaft speed of ½ rpm.

This latest Telechron model was developed especially for use in domestic oil-burner controls, in commercial stokers and oil burners, in delayed-action relays in industrial control mechanisms. It is readily adaptable to many timing, switching, recording and control equipment.

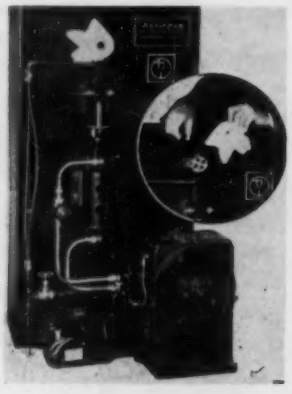
Like all Telechron motors, the new ½ rpm model is self-starting and reaches synchronous speed almost instantly. Its conservative torque rating insures dependable operation. Since it operates in perfect synchronism with all commercial frequencies, *it can't run faster or slower.* Precision engineering and building, coupled with Telechron's exclusive oiling system, assure years of trouble-free service.

For over 25 years, Telechron has been the largest producer of synchronous electric motors. Every one is Underwriters Laboratories approved. That's your assurance of accurate service, low-cost maintenance. Why not let Telechron *application engineers* answer your timing questions? Address Motor Advisory Service, Dept. B, Telechron Inc., Ashland, Mass.

The first and favorite synchronous timing electric motor

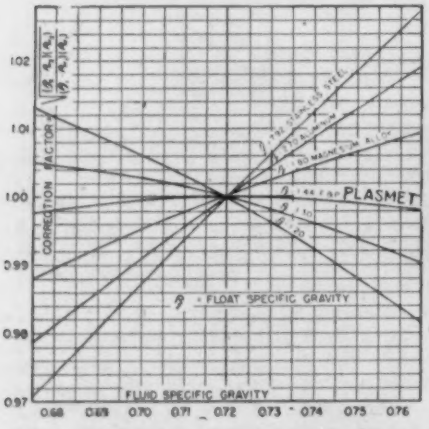
Telechron
REG. U.S. PAT. OFF.
SYNCHRONOUS MOTORS

of four current coils: 1/5/12.5/50 amp. All coils carry 200% current continuously, so that service meters of all ratings up to 100 amperes can be tested." —R. Faille, Apparatus Dep't, General Electric Co.



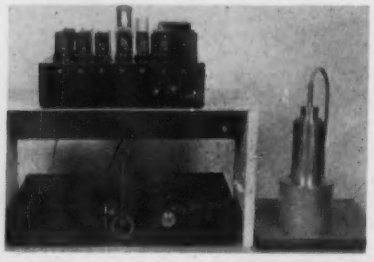
1941. "Combined mechanical and pneumatic positioning and power amplification unit, the Askania pneumatic cam follow-up."—T. M. Lowe, Askania Regulator Co.

1941. "Autoflight Instruments developed the 'Microtorque Potentiometers,' small precision-wound variable resistors designed to produce large electrical outputs for small mechanical inputs . . . 0.003 oz.-in. of torque for operation, dissipate up to 2 watts . . . particularly useful in aviation testing instruments . . . and for adaptations to position and rate gyros." — Peyton Carroll, Autoflight Instruments.

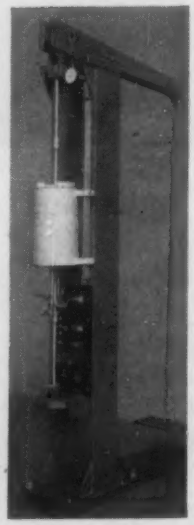


1941. "Inherent automatic density compensation not requiring the use of adjustment linkages or separate measurement of fluid density was achieved by use of metering floats having twice average fluid density, a possibility recognized from study of the mathematics underlying variable-area meter operation."—Kermit Fischer, Fischer & Porter Co.

1941. "Our greatest [war] contribution was to mass produce marine chronometers with completely interchangeable parts. This had never been done before. It made possible our delivery of over 10,000 chronometers to the armed forces from February 1942 to V-J Day." —R. Waddell, Hamilton Watch Co.



1941. "Ionization chamber (right) with amplifier and scaler (left) designed at the NBS for counting alpha particles emitted from films containing radioisotopes." — Hugh Odishaw, National Bureau of Standards.

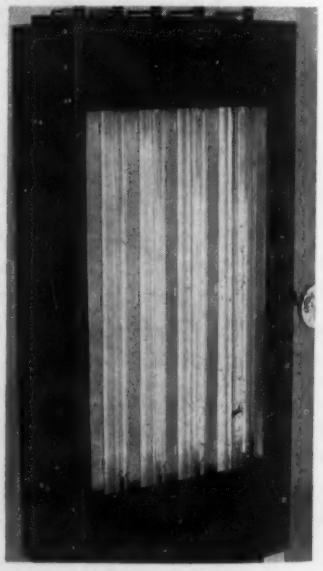


1941. "The Baldwin Lever Arm Creep Testing Machine was outstanding for two reasons: incorporation of a new type of extensometer and provision for creep testing at temperatures to 2200°F. . . . Elongation is indicated by a revolution counter which counts the number of breaks in electrical contacts in a circuit, a break being made at each increase of 0.000025" in length of the specimen. Another revolution counter indicates time in units of 0.1 hour."—M. G. Van Voorhis, for Baldwin Locomotive Works.

1941. "L&N introduced Duration-Adjusting Type of Micromax Electric Control, a unique method of regulating the heat input to an electric furnace by feeding power in impulses of variable duration. . . . made it possible to throttle electric power without loss and without need for costly regulating accessories. It brought the benefits of complete automatic control, with proportional action and automatic droop correction, to users of electrically-heated equipment. The 'rate of approach' feature [see 1940] soon became a standard part of this control method."—H. M. Parshall, Leeds & Northrup Co.

1941. ". . . beginning of mass production of the Sperry A-5 Gyropilot for use in the famed B-24 Liberator bombers. . . . an electric automatic pilot incorporating a new type of [a-c.] signal system and other features. . . . the novelty was the manner in which the signals were modified electronically to include a rate factor (1st derivative) and acceleration factor (2nd derivative) in addition to the conventional displacement signal. . . . a higher degree of stabilization of aircraft . . . than ever before. . . . When coupled with the AAF Type S-1 Bombsight, . . . played a vital role in the bombing of Germany."—C. H. Jones, Sperry Gyroscope Co.

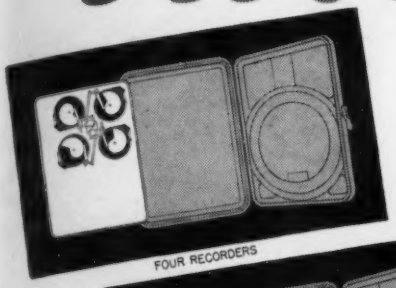
1941. "Phase Microscopy. Developments on the Spencer Phase Microscope commenced in 1941. Of a theoretical and experimental nature, they finally led to the manufacture of a variety of diffraction plates . . . made in several degrees of absorption and retardation . . . greatly enlarged the scope and applications of phase microscopy . . . possible to see details of specimens having small optical path differences or small differences in light transmission." — J. V. Cockin, American Optical Co.

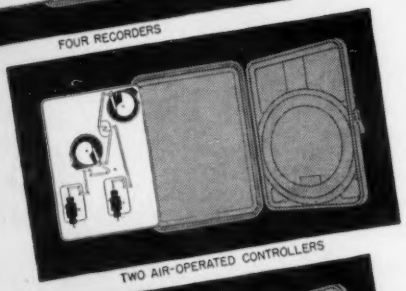


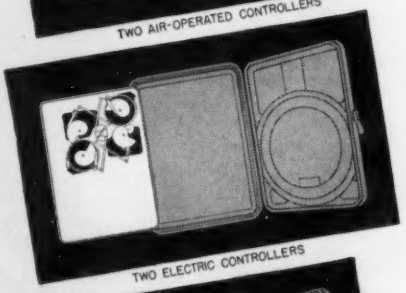
1941. "The first multiple-stage 'molded-in'-guide transparent metering-tube logarithmic-scale high-capacity flowmeter . . . for testing aircraft carburetors. (The first *single*-stage variable area flowmeter with this type of metering tube was built and tested in 1939.)"—Claude E. Cox, President, Commercial Research Laboratories, Inc.

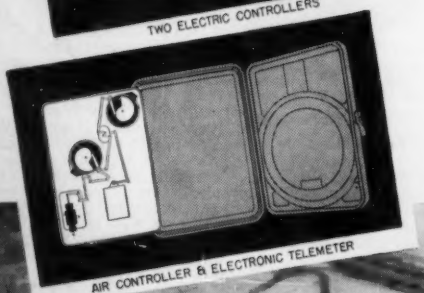
these and 100,000 more

FROM 4 CIRCUITS AND 8 BASIC PARTS


FOUR RECORDERS


TWO AIR-OPERATED CONTROLLERS


TWO ELECTRIC CONTROLLERS


AIR CONTROLLER & ELECTRONIC TELEMETER

What's your control problem? Flow—temperature—level? Are you using solids—liquids—gases?

No matter what you process, four basic circuits and eight basic component parts will give you more than 100,000 different electronic measuring and controlling combinations. That's how Bailey has simplified controls for processing industries.

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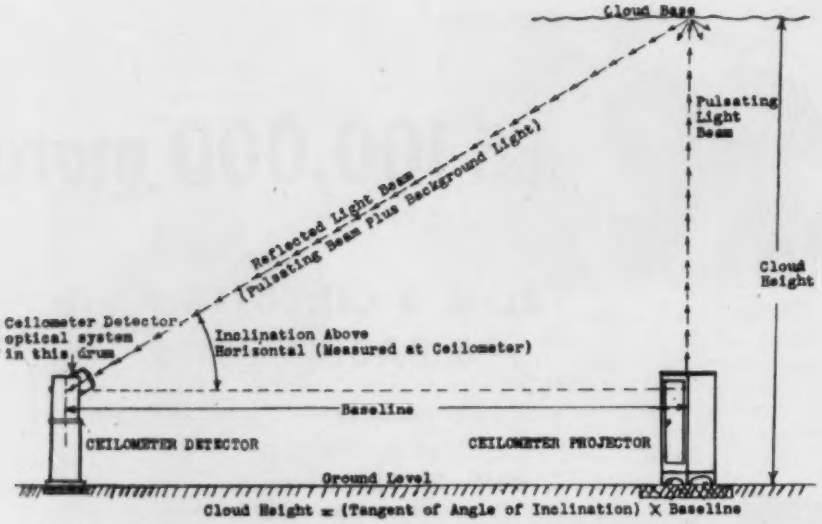
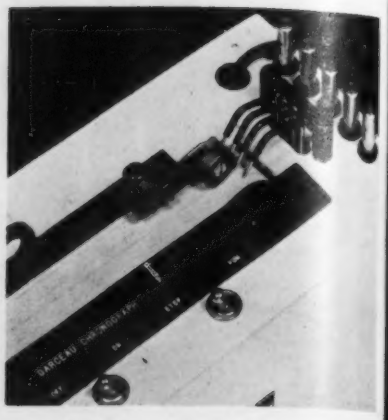
P-17

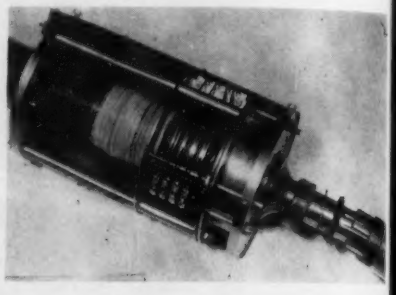
4 + 8 works here at the Barberton Plant of Pittsburgh Plate Glass Company, Columbia Chemical Division


Cloud Base
Pulsating Light Beam
Reflected Light Beam (Pulsating Beam Plus Background Light)
Cloud Height
Ceilometer Detector optical system in this drum
Inclination Above Horizontal (Measured at Ceilometer)
Baseline
CEILOMETER DETECTOR
CEILOMETER PROJECTOR
Ground Level
Cloud Height = (Tangent of Angle of Inclination) X Baseline

1941. "The 'Ceilometer' System is a combination of instruments and equipment developed by the Weather Bureau to determine cloud height. . . . The projector directs a narrow, intense beam of light to the zenith where it is scattered at the cloud base. This scattered light is picked up by the detector, whose optical system continually scans the projector beam. Projector and detector are separated by approx. 1000 feet. . . . The detector is able to pick out the projected spot in full daylight, since the projector beam is modulated at a fixed frequency and the photoelectric amplifier at the detector is tuned to that frequency. The recorder (not shown in diagram) records the time, output of detector, and angle of detector optical system . . ."—W. R. Thickstum, Chief, Instrument Division, Weather Bureau.

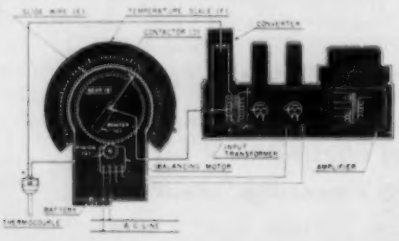


a multiplicity of channels were made for a great number of purposes . . . tape speeds of the order of a few centimeters per day up to several meters per second."—Lovett Garceau, Electro-Medical Laboratory, Inc.



1941. "Baldwin's 'SR-4 Torquemeter' based on bonded resistance wire strain gages, introduced an entirely new principle of torque measurement, i.e. of determining torsional strain at the surface of a shaft instead of the angle of twist. This avoids: (1) transmission of angular deflection through uncertain clamping devices; (2) distortion from centrifugal forces at even the highest speeds; (3) errors from vibration. Slip ring trouble is prevented by a revolutionary improvement in measuring circuits. Indication may be the average, dynamic or both; and indicating and recording equipment of various types may be used. The principle is also applied for thrust measurements, and combination thrust and torquemeters have been developed as well as thrustmeters."—M. G. Van Voorhis, for Baldwin Locomotive Works.

1941. "Brown Instrument Co. brought out a radically different type of [circular chart] recording potentiometer, the 'ElectroniK.' . . . eliminated delicate galvanometer movement and involved mechanism . . . As a result, it was more rugged and sensitive, had fewer moving parts to wear or go out of adjustment, and was unaffected by mounting position. However, the most important feature of the new instrument was the elimination of nudging or periodic rebalancing. . . . eliminating the measuring lag which resulted from the old cyclic balancing action. . . . The 'ElectroniK' potentiometer operates on the null balance principle by balancing an unknown emf. against a known voltage from a battery. When a difference between the two exists the instrument instantly reacts by moving the contact on the potentiometer slidewire to a new null point by means of a balancing motor. Operation and rotation of the balancing motor in the proper direction are accomplished through the electronic unit. . . . The balancing motor is a two-phase motor: its direction of rotation depends upon the phase relationship of the voltages applied to its two windings. Since the phasing is determined by whether the thermocouple emf. increased or decreased, the motor rotates accordingly. . . . continually maintains the potentiometer at the null point. . . . In addition, the 'ElectroniK' continuous-balance principle was incorporated into the first self-balancing precision indicating potentiometer for reading the temperatures measured by one or more thermocouples. The 'Precision Indicator,' as this instrument was called, provides a highly accurate and very sensitive indicating pyrometer with a fixed hairline pointer and a movable scale which combine to eliminate parallax error."—C. C. Roberts, Brown Instrument Co.



1941. "Magnetic-drag Tachometers for Aircraft . . . consisted essentially of a three-phase a-c. generator mounted on the engine, and an indicator that consists of a synchronous motor operating a magnetic-drag assembly. . . . G-E engineers perfected the system and designed generators and indicators that were light, small, reliable, and able to hold the required accuracy through a temperature range from —35°C. to 45°C. . . . G-E tachometers became standard for both Army and Navy planes."—R. Fallie, Apparatus Dep't, General Electric Co.

1941. ". . . In this year the Laboratory, which had borrowed many techniques from the communication and instrument industries, began to repay this debt by adaptations of medical instruments for industrial and ordnance uses. . . . 'Inertialess Chronograph' . . . used telegraph fascimile paper with a non-moving stylus. To mark paper, the current supply (a few milliamperes) was interrupted by contacts attached to mechanism under test. . . . Instruments of simple design and with

SEVENTH "GALLERY"

America's Tough First Two Years *of* World War II

1942 *and* 1943

1942. "TAG designed liquid-gas dial-indicating thermometers for nitrogen and oxygen successfully calibrated down to minus 325°F."—George Terhune, C. J. Tagliabue Mfg. Co.

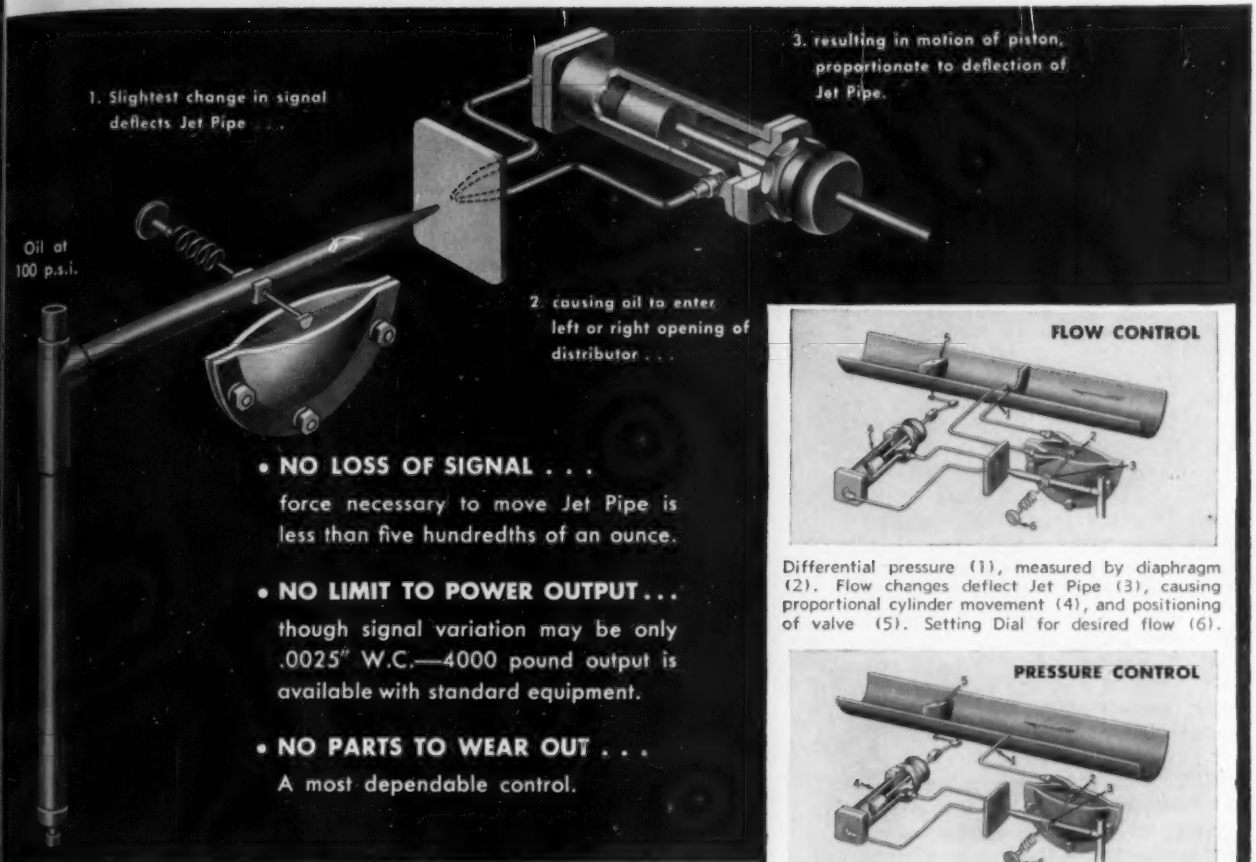
1942. "The first portable automatic high-capacity calibrating stand using the automatic weighing method for calibrating high-capacity liquid flowmeters."—Claude E. Cox, President, Commercial Research Laboratories, Inc.

1942. "The Brown 'Indexet,' developed by Brown engineers, made possible the remote setting of the instrument control point by pneumatic means. Thus, it permits the use of one variable to set the control point of another."—C. C. Roberts, Brown Instrument Co.

1942. "We developed the present Federal Cushioned Movement Indicator which proved to stand the rugged requirements of concerns which had to depend upon green help in the handling of their Indicators."—I. A. Hunt, Federal Products Corp.

1942. "Navy and War Departments called upon us . . . 'Remotomike' [see 1938] was modified for measuring land and grove diameters in gun bores. . . . 'Remotomike' also used extensively in

AN EXCLUSIVE CONTROL PRINCIPLE...

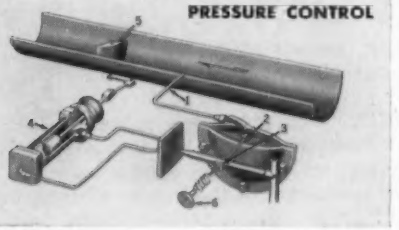

1. Slightest change in signal deflects Jet Pipe . . .
3. resulting in motion of piston, proportionate to deflection of Jet Pipe.
Oil at 100 p.s.i.
2. causing oil to enter left or right opening of distributor . . .

- **NO LOSS OF SIGNAL . . .** force necessary to move Jet Pipe is less than five hundredths of an ounce.
- **NO LIMIT TO POWER OUTPUT . . .** though signal variation may be only .0025" W.C.—4000 pound output is available with standard equipment.
- **NO PARTS TO WEAR OUT . . .** A most dependable control.

FLOW CONTROL

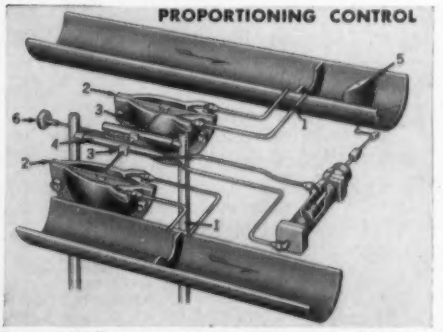
Differential pressure (1), measured by diaphragm (2). Flow changes deflect Jet Pipe (3), causing proportional cylinder movement (4), and positioning of valve (5). Setting Dial for desired flow (6).

PRESSURE CONTROL



Pressure (1), measured by diaphragm (2). Pressure changes deflect Jet Pipe (3), causing proportional cylinder movement (4), and positioning of valve (5). Setting Dial for desired pressure (6).

PROPORTIONING CONTROL



Differential pressures (1), measured by individual diaphragms (2). Signal transmitted to opposite sides of Jet Pipe (3). Any unbalance deflects Jet Pipe (4), causing proportional cylinder movement and positioning of valve (5). Setting Dial for ratio (6).

THE ASKANIA JET PIPE PRINCIPLE

The Askania Jet Pipe converts the most delicate pressures or signals from the source of measurement into rate of movement of a hydraulic cylinder. It consists of the Jet Pipe swinging freely on a hollow vertical pivot into which oil is pumped at high pressure. As the oil stream leaves the nozzle of the Jet Pipe it strikes at two closely adjacent distributor openings. The openings are piped to both ends of the cylinder which is connected to valve, damper or other type controller.

The slightest change in the signal moves the Jet Pipe, causing more or less oil to enter the right or left opening. This causes the cylinder to move either to the right or left to correct for the signal variation. As soon as equilibrium is established the Jet Pipe returns to its median position.

For the tough control job . . . for applications where dependability is all important . . . for the processes where accuracy is a necessity . . . and where valves, dampers, or other mechanisms must be moved, the Askania Jet Pipe Controls are the solution. SEND FOR CATALOG 139.

ASKANIA Controls

ASKANIA REGULATOR COMPANY

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. . . many major arsenals . . . automomobile companies making gun tubes . . ."—F. M. Poole, Pres., Poole Instruments, Inc.

1942. "The improved Brown absolute pressure gage became available for processes which operated at pressures low enough to be seriously affected by variations in barometric pressure. . . . With the absolute pressure gage, errors due to variations in barometric pressure are avoided."—C. C. Roberts, Brown Instrument Co.

1942. "Palmer developed the new extruded brass case thermometer, doing away with castings and with the new drawn brass finish, it was possible to furnish a beautiful chrome finish at very little extra. . . . all Palmer thermometers are standard with chrome finish. There are other exclusive features . . ."—A. E. Honningford, Palmer Thermometers Inc.

1942. "Garceau Inertialess Chronograph [see 1941] . . . adapted to indicate very short pulses on slowly-moving tape. This was accomplished by oscillating the styli slowly in a transverse direction at a period of 3 sec. and with an amplitude of about 3/16". Thus, a pulse lasting only a second or so would produce a visible transverse line easily perceptible."—Lovett Garceau, Electro-Medical Laboratory, Inc.

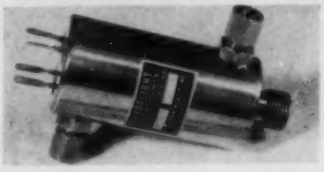
1942. "The projection galvanometer was incorporated . . . line transmission reading scale on the screen together with the images of the master plate and sample spectra . . . permitted operator to fix his eyes on the screen . . . at about this same time, a bridge circuit . . . in the Projection Comparator Densitometer. This increased the zero stability of the densitometer." — Gwen Barkelew, Applied Research Laboratories.

1942. "When the klystron (see 1939) opened the microwave era, man had to devise ways of measuring this new energy . . . development of 'Microline' Instruments that differed radically from those used in the electrical world. . . . wires replaced by coaxial lines and waveguides . . . Voltmeters and ammeters replaced by absolute power meters, frequency meters and impedance meters . . . Rheostats, and voltage dividers replaced by impedance transformers and attenuators. Microwave techniques permit the use of convenient devices such as the directional coupler which takes a measured sample of the power transmitted in the opposite direction."—C. H. Jones, Sperry Gyroscope Co.

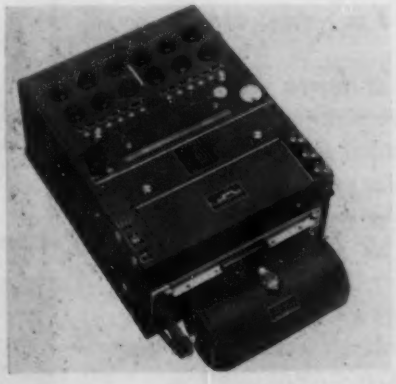
1942. "The first magnetically-damped galvanometer was designed and built for Consolidated's new portable Recording Oscillograph . . . designed and built to meet the needs of AAF flight test problems. The first delivery of Magnetic Airborne Detectors was made to the U. S. Navy. This small instrument was credited by the Navy Department with turning the tide in submarine warfare in the North Atlantic in the early stages of the war. The first Consolidated Mass Spectrometer was delivered to the Atlantic Refining Co. This instrument through its rapid and accurate analysis of unknown mixtures aided immensely in the rapid progress made in the development of high-octane aviation gasoline."—G. E. West, Consolidated Engineering Corp.

1942. "The 'Twin Seal Check Valve' . . . absolutely tight sealing even with grit or particles in the fluid. Suitable for air, oil, water, gas, some chemicals and either vacuum or pressures to 20,000 lbs./in.^{2}."—D. C. Green, Mansfield & Green.

1942. "A colorimetric indicating gel that detects and estimates less than one part of carbon monoxide in 500 million parts of air (a sensitivity more than 100 times that of former chemical indicators) was developed by the Gas Chemistry Laboratory of the NBS for war time uses of the armed services. It also detects 0.001% by volume in less than one minute, and determines physiologicaly significant amounts (0.01% to 0.4%) in approximately one minute at ground level. The indicator has made it possible to diagnose carbon monoxide poisoning by analyzing exhaled air instead of taking a blood sample for analysis. The complete kit is pocket size."—Hugh Odishaw, National Bureau of Standards.

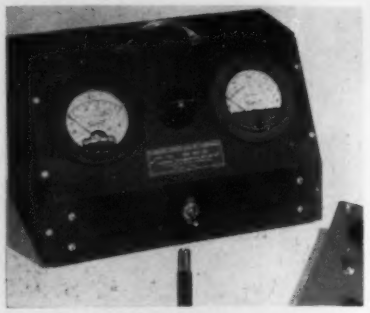


1942. "Development of 'Autoflight Transmitters' . . . generally comprised a primary element (controlled-action bellows), a mechanical coupling, and a 'Microtorque' variable resistance unit (see 1941). . . . pressure transmitters, then linear-accelerometer, vane, altitude, and slack-diaphragm transmitters."—Peyton Carroll, Autoflight Instruments.



1942. "The 'Type S8-B' Oscillograph made the oscillograph an instrument for the engineer rather than for the laboratory researcher alone, for it contained positive governor-controlled chart drive, instantaneous selection of 16 record speeds over a speed range of 120-to-1, automatic record-numbering, automatic record-length control, precision tuning-fork timing . . . and provision for as many as 48 channels on a single record."—C. M. Hathaway, Chief Engineer, Hathaway Instrument Co.

1942. "'Eng-Sol Dehydrator' was engineered to replace filters where absolutely clean dry air was essential. 10 cfm of clean air at 80 lbs./in.^{2} . . . outstanding because no filter could deliver air of such purity . . . air purified without pressure drop."—D. F. Cook, Passaic Analytical Laboratories.



1942. ". . . the 'Type 501' metal thermocouple gage and 'No. 701' control panel as a rugged vacuum gage for industrial use . . . calibrated to indicate pressures directly and continuously from 1 to 1000 microns of mercury absolute."—Stanley Heck, National Research Corp.

1942. "The 'Twin Seal Hydrostatic Test Unit.' In Fig. 1 it is shown used for portable test purposes. Filled with oil it weighs approx. 10 lbs., is capable of developing pressures to 10,000 lbs./in.^{2}. In Fig. 2 it is shown in operation with dead-weight testing attachment . . . ranges to 10,000 lbs./in.^{2}."—D. C. Green, Mansfield & Green.

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"Half a Century of Instrument Know-How Is Built into These Fine Electrical Meters" . . . in sizes from 2″ to 7″ in a wide variety of case shapes and mounting arrangements.

No matter how specialized your requirements may seem, the chances are that Triplett has already engineered and tooled up for a design so nearly akin that a few inexpensive changes or additions will suffice.

Triplett . . . . A Self Contained Electrical Instrument Factory . . . From screw machine parts to plastic moldings, from moving elements to dial faces, all are fabricated in Triplett's modern air-conditioned factory. Equipped with special humidity and dust controls in assembly rooms. This self-contained factory means one overall profit markup with better quality control and consequent savings to you.

Complete meter satisfaction is yours in performance, appearance, and dependability. Let Triplett add lustre and give precision performance to your instrument panel.

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Round or Square

A.C., D.C.,
R.F., Rectifier or Dynamometer

Triplett can supply on short notice electrical meters in 2″, 3″, 4″, 5″ 6″ and 7″ sizes in round, rectangular, square and fan shapes; wide flange, narrow flange, flush, projection and portable. Molded and metal cases. Rear illumination, special dials and other features available on most models.

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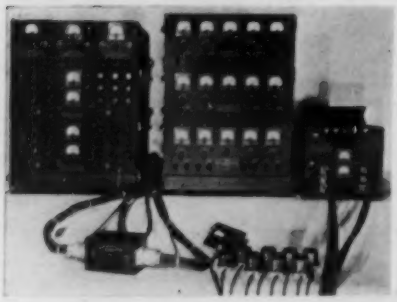
Representatives in Principal U. S. and Canadian Cities

TRIPLETT

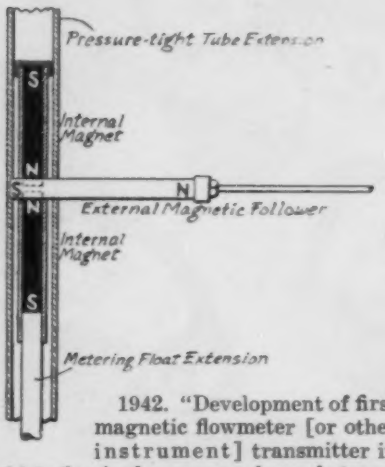


1942. "The first complete set of measuring and recording equipment was delivered to the Army Air Forces . . . credited with saving many months' time in the design of military aircraft." —G. E. West, Consolidated Engineering Corp.

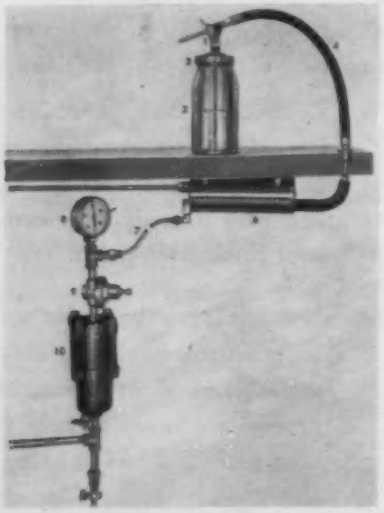
1942. "DuMont brought out the 'Type 224' (now known as Type 224-A) Cathode-ray Oscillograph. The wide range response of this instrument provided faithful reproduction of wave-forms with steep fronts and large harmonic content, thereby permitting the study of signals such as pulses and square waves, where frequency components as high as 5 Mc. are involved. In that same year Du Mont produced the 'Type 241' Cathode-ray Oscillograph designed for applications requiring the examination and observation of audio and video frequency signals above the operating range of the usual oscillographs. Non-sinusoidal wave shapes within the frequency range of the instrument, such as pulses and square waves, are not distorted either from lack of compensation or by over-compensation for the high frequencies, due to the design of this instrument."—J. H. Ruiter, Allen B. DuMont Laboratories.

1942. "For the first time smaller vessels were equipped with gyro-compasses: the Mark 18 Gyro-Compass for landing craft. . . . now used commercially (photo shows installation in a fishing vessel.)"—C. H. Jones, Sperry Gyroscope Co.

1942. Elimination of Slidewire and Contacts from Null-balance Instruments. "Foxboro introduced the 'Dynalog' line of instruments, the outgrowth of 16 years of industrial electronic experience with the 'Verigraph' Recorders, and making complete use of electronic principles to eliminate, for the first time, all moving contacts and slide-wires from a null-balance instrument, through the use of a balancing capacitor. Galvanometers, batteries, high-speed motors, and gears, also were eliminated by full use of electronic principles. This makes possible the highest pen speed available, without increasing wear and with no regular maintenance needed." — Robert Barton, The Foxboro Co.

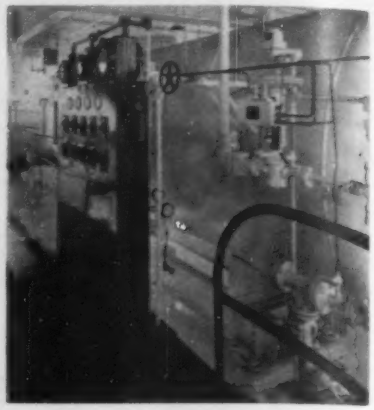


1942. "Development of first magnetic flowmeter [or other instrument] transmitter in which 'loss' of correspondence between actuator and follower is impossible because design is such that the greater the deviation from correspondence, the more force is available to drive follower and actuator back to a corresponding position. Thus, basic defect of magnetic couplings was eliminated." — Kermit Fischer, Fischer & Porter Co.



1942. "'Eng-Sol' high-velocity sprayer and air heater combination for complete removal of surface contaminations from precision parts. Mixture of air and solvent . . . twofold cleaning action: special solvent dissolves soluble matter; air blast drives out insoluble material and flushes away dissolved remainder . . . helped make possible wartime mass production of fine instruments."—D. F. Cook, Passaic Analytical Laboratories.

1942. "Glass Jewels for Instrument Bearings. When the war cut off the supply of [imported] sapphire jewels, . . . [instrument people] were greatly alarmed. By February, 1942, the situation had become desperate. But G-E had accelerated the development of a V-shaped jewel of special hard glass and of a method for making it . . . met all the requirements for small precision instruments . . . Only 16% was used for G-E instruments; the remainder went to other instrument manufacturers to fill wartime need."—R. Faille, Apparatus Dep't, General Electric Co.



1942. "Continuous Automatic Ethyl Blender by %Proportioneers, Inc.%, . . . a modification of the standard weigh tank and educator unit developed by Ethyl Corp., . . . added equipment to provide continuous automatic blending of gasoline with Ethyl fluid, in any dosage from 0.2cc. to 6cc. per gallon despite variations in rate of flow of gasoline being treated. The new control system may be tied into any existing plant by making a T connection. In operation, untreated gasoline flows from storage through a Venturi meter tube; variations in the rate of gasoline flow are measured by flow control transmitter which actuates the gasoline totalizer on the instrumen panel and also regulates the rate at which tetraethyl may be withdrawn from the Ethyl weigh tank through the Proportioneers scale head." — Carleton Goff for %Proportioneers, Inc.%

1943. "First Rotameter constructed with rigid cast frame."—H. W. Gripton, Schutte & Koerting Co.

1943. "We took on the sale of Electronic Gaging equipment."—I. A. Hunt, Federal Products Corp.

1943. "'Model K' Tester: First compact, inexpensive, all-purpose tester." —R. E. Dillon, W. C. Dillon & Co.

1943. "Research and development of the Multisource Unit began in 1941, and was carried through 1942. Its production started in 1943." — Gwen Barkelew, Applied Research Laboratories.

1944. "TAG engineered a special Indicating Potentiometer for a prominent oil company. . . . 24 continuous indicating points in a single panel. . . . 'Celectray' Photoelectric principle. . . . ability to indicate trends in a tower." — George Terhune, C. J. Tagliabue Mfg. Co.

1943. "The radioactive glow-discharge lamp was brought out. Its purpose is

Explosion-Proof . . .

PRESSURE OPERATED SWITCH . . .

★ Compact—Lightweight

★ Proof Pressures—to 150 PSI

★ Differentials—1 PSI to 20 PSI

★ Listed for Hazardous Locations

★ Pressure or Vacuum Operation

MODEL No. 440

Durable Model 440 incorporates the explosion-proof Micro Switch. This single pole, double throw switch is Underwriters' Listed for hazardous locations.

Separate housings for pressure and electrical controls permit independent adjustment for pressure or electric systems. Electrical adjustment may be made without reducing the actuating pressure. Pressure adjustment may be made without exposing electrical circuits.

Our competent engineering staff will be pleased to consider your specific engineering problems. Write today!

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MANUFACTURERS OF *George A. Starbird* EQUIPMENT

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Low cost gas analysis!

ACCURATE...
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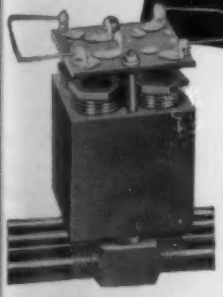

GOW-MAC cells require no special instruments—give excellent results with standard accessories found in any laboratory or instrument department.

AUTOMOTIVE ENGINEERS AND PETROLEUM ENGINEERS

Consult These Authoritative Articles On Combustion and Refining Tests:

MINTER, C. C.—Industrial and Engineering Chemistry, Ind. Edition 17, 687 (1925), "Combustion in the Gasoline Engine." Journal Society Automotive Engineers 16, 613 (June 1925), "A New Method of Exhaust Gas Analysis." National Petroleum News 25, 33 (June 1933), "Exhaust Gas Analysis as a Method of Determining Carbon Content of Gasoline."

D'OUVILLE, E. L., and K. E. HOWE —Petroleum Refiner, June 1947 "Thermal Conductivity Cells for Gas Anaylysis in Fischer-Tropsch Synthesis."

Inquiries from Laboratory Supply Houses Should be Addressed to Dept. SD.

GOW-MAC INSTRUMENT CO.
22 LAWRENCE ST., NEWARK 5, NEW JERSEY

MERIAM INSTRUMENTS FOR INDUSTRY

For 37 years we have been solving measurement problems by supplying standard or special instruments to accurately measure pressures, vacuums and flows of liquids and gases. We have constantly improved, developed and diversified the line so as to meet fully all needs of the field.

U-TYPE MANOMETERS

The Clean-Out Manometer (at left) for line pressures up to 100 lbs. per sq. in. A wing nut permits the Manometer body and tube to be disconnected from the head — the tube cleaned with a brush furnished or tube replaced, and the instrument reassembled without disconnecting the head section from the piping. Send for Bulletin No. 1.

The Model A-995 WM Manometer for line pressures up to 400 lbs. per sq. in. These instruments are built with heavy walled annealed straight Pyrex tubes, gland packed top and bottom in steel end blocks and clamped to the body at fixed intervals to prevent distortion. Catalog Sheet A-995 WM gives complete details.

WELL-TYPE MANOMETER

Model A-275 WM (at left) is a direct reading type for line pressures up to 150 lbs. per sq. in. Standard construction; ranges — from 6" to 24". Wall mounted type shown; also available in flush mounting. Ask for Catalog Sheet A-275 WM.

SIGHT FEED BUBBLER

This Sight Feed Bubbler with 2½" dia. bowl of Pyrex glass is good for line pressures up to 50 lbs. per sq. in.; of plastic, for pressures up to 100 lbs. Sturdily built with brass or semi-steel body. Supplied in ring type (shown) and strap type. Needle valve controls bubbler rate. Ask for Bulletin 21.

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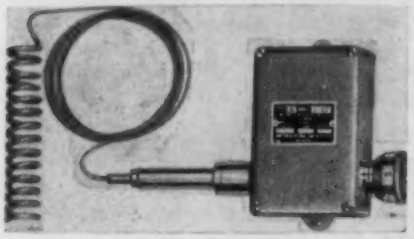
ESTABLISHED 1911

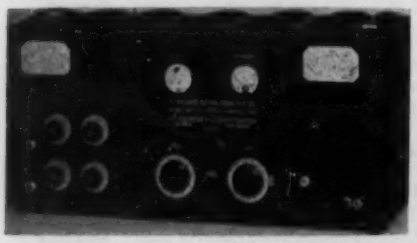
MANOMETERS, METERS AND GAUGES FOR THE ACCURATE MEASUREMENT OF PRESSURES, VACUUMS AND FLOWS OF LIQUIDS AND GASES

to supply the means of securing a constant striking voltage through the use of radioactive sources — preferably a radioactive light source."—Henry Wolfson, Coördinator of Research, Canadian Radium & Uranium Corp.

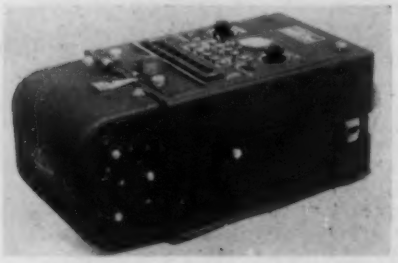


1943. "The better features of the 'Type B' and 'C' controls (see 1940) were combined and the 'Type K' Thermostat evolved."—E. C. Clark, Jr., for United Electric Controls Co.

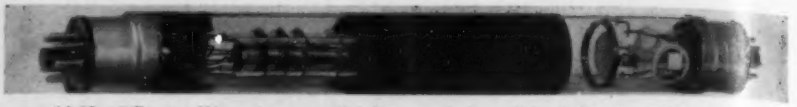
1943. "The Brown 'ElectroniK' strip chart potentiometer become available for industrial use. . . . also met the demands both as to speed and accuracy in such laboratory devices as spectrometers, dewpoint recorders, polarographs, gas analyzers, etc." [See 1941 for original circular-chart "ElectroniK"]—C. C. Roberts, Brown Instrument Co.



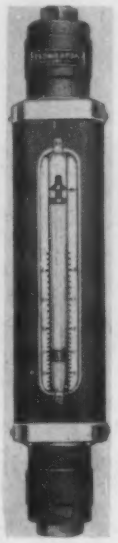
1943. "The 'Model 84' was the first UHF Signal Generator to include a self-contained pulse modulator . . . accurately measured output variable from 0.1 microvolt to 0.1 volt in the frequency range of 300 to 1000 Mc."—E. M. Weed, Measurements Corp.



1943. "A complete high-speed recording oscillograph with . . . convenience features . . . was required, that could be used in . . . fighter aircraft and tanks. 'Type S12-A' Oscillograph was the result, the first complete 12-element oscillograph that could be classed with portable instructments. . . . weighing only 35 lbs., it included: temperature-controlled galvanometers, automatic record-length control, consecutive record numbering, magazine loading, [etc.]. . . ." —C. M. Hathaway, Chief Engineer, Hathaway Instrument Co.



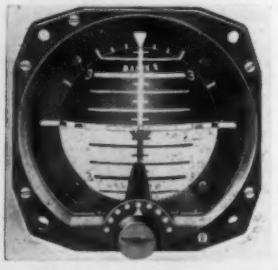
1943. "Controlling type cathode-ray tube, the Askania 'Electrobeam' Tube."—T. M. Lowe, Askania Regulator Co.



1943. "First (and still only) continuous viscosimeter developed, requiring no withdrawals of samples from main flow line, no intermittent operation. Liquid or gas viscosity metered continuously by a method which permits automatic control of viscosity as well." — Kermit Fischer, Fischer & Porter Co.

1943. "Standby aircraft compass developed by the NBS for the Bureau of Aeronautics, Navy Department . . . damped solely by eddy currents produced in a copper cup by the two Alnico V magnets. It is water-proof, floats in water, has a tilt range of ± 15°, and is practically shock-proof. Diameter, 1¾"; weight, 0.065 lb."—Hugh Odishaw, National Bureau of Standards.

1943. "Combustible Gas Detector for measuring the amount of combustible gases and vapors present in gas-air and vapor-air mixtures. . . . percent of the lower explosive limit . . . is continuously recorded on a 12" chart. . . . a signal device to give warnings when concentration of mixture approaches explosive concentrations."—G. P. Lonergan, The Bristol Co.



1943. ". . . Dive bombing presented an extremely vital problem. Angles required were more acute than in any other type of flying . . . need for an instrument that gave the pilot continuous attitude indications in respect to the horizontal plane, through all aircraft maneuvers. For this purpose the Sperry Attitude Gyro was developed. Requiring no caging, it had 360° of freedom and allowed the pilot to calculate his attitude with respect to the ground at *any* point of his flight."—C. H. Jones, Sperry Gyroscope Co.

1943. "Fluxmeter. An important means of defense against magnetic mines during the war was . . . degaussing. . . . passing electric current through several turns of wire wrapped around the hull of a ship to neutralize the effect of the earth's magnetic field on the hull and the equipment inside. Before a ship could be degaussed, it was necessary to secure data on her magnetic characteristics. . . . special fluxmeters developed for this purpose were set up at some convenient location and connected to coils on the harbor bottom. Ships to be degaussed were passed over them, and from the fluxmeter readings the effect of the ship on a magnetic mine could be quickly determined. These instruments found important peacetime applications."—T. A. Rich, Gen'l Eng'g and Consulting Lab., General Electric Co.

1943. "Pneumatic Indicating Potentiometer Controller added to TAG 'Celectray' line. By employing a beam of light, a mirror galvanometer and a phototube, utilized in 'Celectray' design since the thirties, it was possible to offer the simplest pneumatic potentiometer controller ever presented to the industry. Six types of control: On-off; fixed narrow throttling; adjustable throttling with manual reset; adjustable throttling with automatic reset; adjustable throttling with quick response and automatic reset."—George Terhune, C. J. Tagliabue Mfg. Co.

1943. "The G-E puncture tester originated in the Company's need for better means of testing its own shipping containers for meters, instruments, lamps, [etc.] . . . Previous testing methods had given results at variance with actual experience . . . It was felt

TIME as a factor of CONTROL in Industry

NEW ROCKFORD 4 - FUNCTION MOLDING MACHINE FOR THERMOSETTING PLASTICS ... *timed by Cramer*

Measuring, preforming, preheating, molding — the four functions of molding thermosetting plastics combined in one machine! A development of the Rockford Machine Tool Co., all movements are hydraulically powered, electrically controlled . . . automatically timed through the complete operating cycle by Cramer Time Delay Relays.

Another product where dependable control is essential to performance . . . **timed by Cramer.**

Specialists in TIME as a factor of CONTROL, Cramer has developed a wide range of devices for a great variety of commercial and industrial duties. If the performance of your product depends on precision timing, consult Cramer

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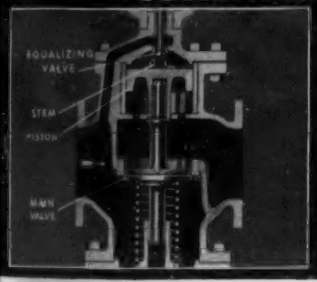
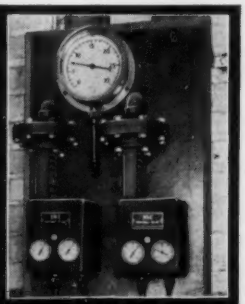
ICR48

Automatic STEAM PRESSURE CONTROL





Control Pilot

Single Seated, fully balanced Regulating Valve

The LESLIE Pressure Controller is particularly useful for supplying intermittent make-up to a low pressure system from a high pressure line. The action is positive and follows low pressure fluctuations with fidelity. The sequence is simple: Low side pressure changes operate the diaphragm in the control pilot which in turn regulates the pressure of the operating medium—air, gas or liquid—on the diaphragm of the regulating valve in the high pressure line.

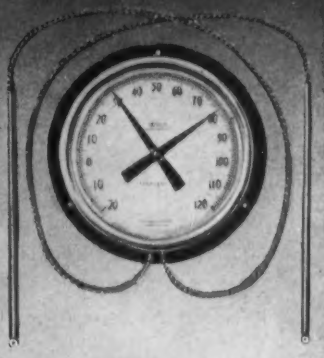
Write for Bulletin 462 for the complete story.

TRADE LESLIE MARK

LESLIE CO.
229 Grant Ave., Lyndhurst, N. J.

PRESSURE REDUCING VALVES • • PRESSURE CONTROLLERS
PUMP GOVERNORS • • • TEMPERATURE REGULATORS
SELF CLEANING STRAINERS • • LESLIE-TYFON WHISTLES

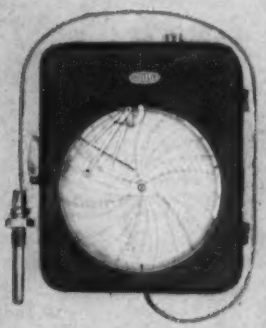
FOR CONSTANT DEPENDABILITY *Install* MOELLER DIALS and RECORDERS



Remote Reading Type, Mercury actuated with separable socket connection. Back connection or flush mounting.

Duplex, mercury actuated, plain bulb type indicates temperatures at two separate points.

TEMPERATURE RECORDING TYPE



Single and multiple pen, Remote Reading types in rectangular or round cases.

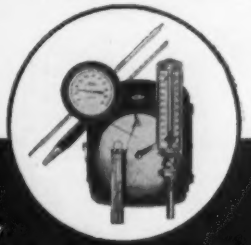
Moeller Dial or Recording Thermometers can be furnished with electrical contacts.

FOUR GENERATIONS have depended upon the accuracy of Moeller instruments.

FOUR GENERATIONS have relied upon the unfailing precision of all Moeller products.

***Eighty* years of such confidence in proven performance establishes the name Moeller as a guarantee of perfection in the engineering and manufacture of temperature indicating and recording instruments.**

INDUSTRIAL, LABORATORY AND RECORDING THERMOMETERS
THERMOSTATS • HYGROMETERS
HYDROMETERS • PSYCHROMETERS
AND MARINE SPECIALTIES



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INSTRUMENT COMPANY
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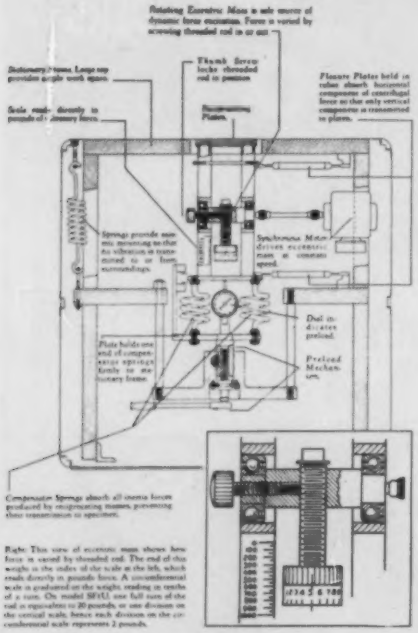
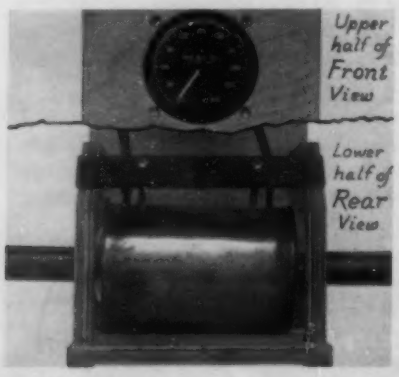
Representatives in Principal Cities

that better results could be obtained by means of a machine striking a blow similar to . . . service. A pendulum with a projecting arm punctures the specimen; a pointer measures the pendulum-swing angle."—C. J. Falk, Gen'l Eng'g and Consulting Lab., General Electric Co.

1943. "The Sonntag 'Model SF-01-U' Fatigue Testing Machine was the first universal type (*i.e.*, for measuring fatigue strength in tension, compression, flexure, or combinations of these forces) utilizing the constant force principle. Constant load is produced by a mechanical oscillator, essentially an eccentrically-mounted

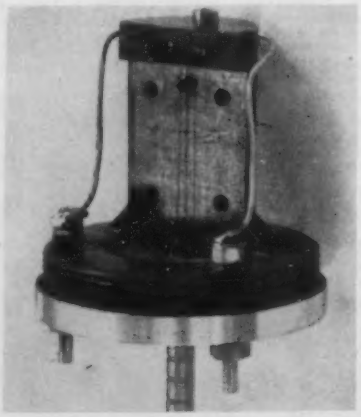


mass driven through flexible couplings by a synchronous motor. Among reasons why a constant load application is desirable in fatigue or simulated service testing: (1) It avoids the need to determine load deflection characteristics by calculation or calibration: (2) It avoids interruption of a test for checking and readjusting for changes in stiffness of the specimen: (3) Complete fracture is accelerated after the first incipient failures occur because the same load is applied on the weakened specimen. . . . Five sizes of machines have been developed, from 20 to 20,000 lbs., one of them for high-temperature fatigue testing."—M. G. Van Voorhis, for Baldwin Locomotive Works.



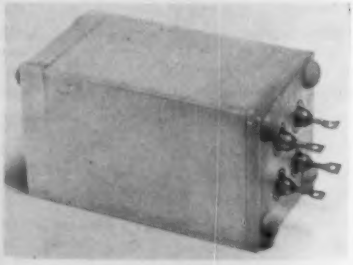
1943. Linear Flowmeter. "A simple, inexpensive flowmeter developed at the NBS in 1943 utilizes glass wool as its primary element, is characterized by: (1) linear indication directly proportional to the volumetric flow; (2) wide flow range; (3) resistivity that may be varied to suit a wide range of flows. The model shown was constructed from a simple canister and a standard differential-pressure gage."—Hugh Odishaw, National Bureau of Standards.

1943. "The DuMont 'Type 247' Cathode-ray Oscillograph was announced . . . enabled the investigation of transient as well as recurrent phenomena over a wide range of frequencies . . . was designed to facilitate photographic recording by using high accelerating potentials with the 'Type 5RP-A' c-r. tube. Increased light output from this tube permits 'Type 247-A' to be used with the DuMont Projection Lens, 'Type 2088,' as a projection oscillograph . . . for lecture or demonstration purposes. In that same year the 'Type 248' Cathode-ray Oscillograph was put on the market . . . a portable instrument for the accurate observation and study of microsecond pulses containing frequency components, as high as 10 Mc. Either transient or recurrent phenomena can be displayed, and the instrument accommodates phenomena of inconstant repetition rate. Nor is the leading edge of short pulses obliterated. The accelerating potential applied to the tube is great enough to permit study of extremely short pulses with low repetition rates. Such phenomena usually can be observed only with specialized and costly equipment."—J. H. Ruiter, Allen B. DuMont Laboratories.

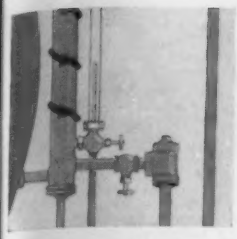


1943. Unbonded-wire Gaging Elements. "Several years prior to 1943, a strain-sensitive copper-nickel resistance wire strain gage was developed, utilizing a grid of the special wire sandwiched between two sheets of thin paper. While this strain gage was extremely useful in measuring surface strains, attempts to adapt it to the measurement of other variables were generally not too satisfactory, . . . In 1943 the Curtiss Wright Corp. Airplane Div. Research Laboratories undertook the development of a pressure transmitter operating on the strain-sensitive resistance wire principle, . . . development program was subsequently taken over by Statham and expanded to cover accelerometers and dynamometers. Numerous instruments incorporating bonded-paper-type strain gages were constructed, but were not entirely satisfactory . . . An important forward step was the development of a pressure transmitter whose operating element consisted of a diaphragm with a hook attached at the center. Several loops of strain-sensitive wire were wound between this hook and a fixed post on the frame. This winding formed one arm of a Wheatstone bridge; a second winding between fixed posts formed an adjacent arm and provided temperature compensation. . . . This instrument (illustrated) while not the first to use unbonded strain sensitive wire, incorporated several design features which made possible the development of a rugged, sensitive and accurate unbonded strain gage . . . and put an end to attempts to build instruments around the bonded strain gage."—R. D. Meyer, Statham Laboratories.

1943. "Multiple Range Comparator Gage. The newly-organized (1942) Metron Instrument Co. developed the first multiple-range Comparator Gage for the close measurement of mechanical dimensions. . . . extended the usefulness of a single comparator instrument from a tolerance ratio (full scale ÷ minimum useful defection) of about 10 to approximately 200. A comparator gage with a single range of ±0.0004″ was usually suitable for checking tolerances only between 0.0004″ and about 0.00004″. The new multiple-range gage having ranges ± 0.00025″, 0.0005″, 0.0025″ and 0.005″ was useful for checking tolerances between 0.000025″ and 0.005″. . . . increased the range coverage 20 times; the great majority of the usually-encountered tolerances could thus be checked with a single instrument. . . . extensive search for some type of inductance bridge circuit which would permit independent adjustment of sensitivity and balance point. . . . found in a four-element variable-inductance network which incorporated rectifiers within the bridge itself. This provided a d-c. output from a 60-cycle a-c. bridge circuit which had zero current at balance, plus or minus polarity depending on direction of off balance, extreme linearity, and sufficient sensitivity without resorting to vacuum-tube amplifiers. . . . characteristics ideally suited for a simple multiple-range system. . . . Other features . . . accurate and stable mechanical zero adjustment . . . indicator located equidistant and close to the work area to reduce eye fatigue . . . gage head was equipped with adjustable spindle pressure which was not only easily adjustable but also calibrated in actual pressure."—F. K. Floyd, President, Metron Instrument Co.



1943. Miniature Accelerometers and Pressure Gages. "In conjunction with the development of radio telemetering systems, Flader engineers pioneered in the design of miniature strain-gage instruments for precise measurements in numerous Government applications . . . made possible the continuous and instantaneous recording of telemetered measurements otherwise impossible to obtain. Out



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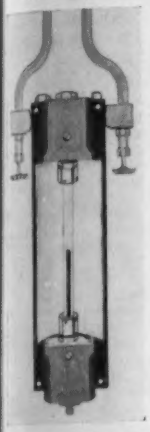
This gage is read conveniently at eye level—even if your tank or boiler is remotely located. Designed to take into account temperature differences between boiler and gage liquids. Simple . . . compact . . . rugged . . . no mechanical parts to get out of order . . . reduces cost of water control apparatus. Write today for details.



Gage connected to boiler water column. Also may be connected directly to boiler drum without column.

- Rugged and compact — glass tubing withstands high steam pressure
- Easily read at wide angles and at greater distances because indicating liquid never contacts indicating glass
- Actuated by concentric mercury tube
- Gages may be installed on a group of boilers and read from one convenient point
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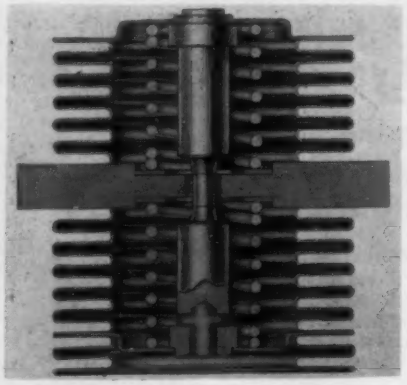
of these developments (which played a significant and successful role in the development of new aircraft and other military products) came . . . instrument designs combining high accuracy with exceptionally small size. . . . The electrical 'Type AS' accelerometers and 'Type PS' differential and relative pressure gages, especially designed for aircraft and missile applications, are available in ranges up to 100 *G* and 100 lbs./in.² respectively . . . particularly suited for applications in aeronautics, telemetering, and industrial research. The accelerometers are approx. 1″ × 1″ × 2¼″ and weigh less than 4 oz. . . . pressure gages approx. 1″ × 1½″ × 2″ and weigh less than 4 oz. The active elements of each instrument are four 300-ohms strain gages connected in a temperature-compensated Wheatstone bridge circuit and bonded to a cantilever beam of special material selected to minimize hysteresis. . . . The electrical output is sufficient for direct operation of manv types of microammeters, recording potentiometers, recording galvanometers, or cathode-ray oscillographe . . . dry-cell power supply is sufficient . . . The instruments are ideally suited to use with carrier systems . . . operating components are sealed in a metal case filled with an organo-silicone fluid to provide the necessary damping in the accelerometers and to provide resistance against vibration fatigue in the pressure gages."—G. O. Haglund, Head, Electro-Mechanics Dep't, Fredric Fiader, Inc.

1943. "The company (then . . . Morey & Jones, Ltd.) introduced 'Model 163 Differential Pressure Indicator' which employed Temperature-compensated Rupture-proof Bellows Unit . . . outstanding development in the field of flow and liquid-level measurement. Previous attempts to employ flexible metal bellows . . . had several basic weak points . . . rupture or distortion if accidentally subjected to a differential pressure much in excess of the instrument range. Vapor or liquid traps were difficult, if not impossible, to remove. These objectionable features were entirely eliminated . . . positive protection against overranging of the most sensitive bellows. It cannot form vapor or liquid traps as only the exterior of the bellows comes in contact with the fluid being gaged. Unit comprises two flexible metal bellows secured to opposite sides of a central support disk. The closed or floating ends of bellows are rigidly connected by a dual valve stem that passes freely through a hole in center of disk. The edges of this hole act as seats for the stem valves that are spaced on opposite sides of the disk. Springs installed between center disk and bellows ends determine differential pressure range of Unit. After assembly, Unit is filled and sealed with a clean low-freezing-point liquid. . . . Travel of bellows beyond its operating range is checked by valve seating on center disk. Simultaneously, the incompressible liquid trapped within by closing of valve prevents distortion or damage to bellows. As the valves are constantly immersed in a clean liquid, they are always positive in action. This permits application of full line pressure against either side of Bellows Unit, with opposite side exposed to atmospheric pressure, without causing injury. Temperature compensation: Any tendency of bellows or calibration springs to expand or contract with change in temperature is neutralized by the balanced construction . . . Expansion or contraction of the liquid within the Unit is taken up by a single closed-end bellows convolution attached to the high-pressure bellows. . . ."—C. D. Nolte, Barton Instrument Co.



1943. "Electric Gyro Instruments for Aircraft. . . . original contribution to the war effort, the development of electrically driven gyroscopic instruments was an outstanding accomplishment. At the close of 1943, four types were in production: a horizon indicator, a direction indicator, a horizon control, and a direction control, the latter two being the 'brains' of the G-E Automatic Pilot, as well as indicating instruments for the human pilot. They were the first electrically-driven gyros for aircraft panel mounting to be developed and produced anywhere. . . . Electric drive provides constant speed of rotation independent of altitude, air density, or temperature. . . . The horizon gyroscope erecting device is unique . . . consists of a gimbal-suspended pendulous permanent magnet which acts on a rotating nonmagnetic cup-shaped 'disk' to produce a 'magnetic-damping' torque to restore the rotating element, if displaced, to its proper position with respect to the earth."—R. Faille, Apparatus Dep't, General Electric Co.

Extracts from editorial in January issue introducing *Instruments'* Twentieth Anniversary Feature which began in that issue and will be concluded in the next (April):

THIS Special Issue is not a history but a "historical museum on paper." We fervently hope that no one will refer to it as "a history." Just as there is an enormous difference between a mass of data (the raw material of science) and a science, so there is a difference between a mass of documents (the raw material of history) and a smooth piece of writing that deserves to be called a history.

Some day a history of American instruments will be written. It should be a fascinating best-seller; it might be a dull flop. As a contribution to the proper preparation of such a history, this editorial introduction will recite facts and circumstances. Another purpose is to make readers enjoy this issue with keener zest: Human interest, even drama, pervades the following pages.

But before we go into these details we express deep appreciation of the tremendous amount of work done by the hundreds of contributors: Tens of thousands of man-hours in hundreds of offices, laboratories, and plants have gone into making possible this Special Issue!

THE PLAN.—Burns was right when he wrote about "the best laid plans of mice and men . . . " No finer plan could have been conceived than the one adopted last summer:

(1) The Twentieth Anniversary Issue to be a historical issue, chiefly of "FIRSTS." (In view of the modesty of many old-timers in the industry, the term "outstanding development" was used in addition to the word "first.")

(2) The issue to be made up entirely of contributions mailed to *Instruments;* no historical delving or writing by the editor, because such work would take years instead of months.

THE INVITATIONS.—Various letters and advertisements were prepared last summer, in which the plan was outlined and the simple "rules" explained. It was stipulated that EACH description was to mention WHY the development was outstanding.

"EVERYBODY" INVITED.—The mailing list included all instrument manufacturers; also instrument designers and makers in governmental and private institutions. Thousands of persons not on this list received notification through the magazine *The Instrument Maker.*

HUMAN NATURE FOILS PERFECT PLAN.—Most early contributions consisted of catalogs. The letter usually ran:

All of our latest models are of historical importance. However, I'll forgive you if you don't print pictures and descriptions of all of them. Look over our line; pick out items and send me a list: I'll then send you cuts or photographs.

P.S. Submit your write-ups to me before you print them.

In mid-October a "personalized form letter" was sent to every name on the master list. Extracts:

"Some of you have sent us a mass of booklets and asked us to pick out your historic achievements. Sorry, no can do! You are the one to send us the pictures and to write the descriptions or narratives.

"Each contribution should be SIGNED. Each description should mention WHY the development was outstanding.

"Some of you, who sent us photos and descriptions of new models just brought out, may believe that these new products are as "outstanding" as, say, the first thermometer made in America; but . . . please don't force us to assume the onerous role of censor."

The total number of contributions could not be counted because most of them were not usable, being the thousands of items in catalogs. This raw material would fill an eight-foot bookshelf, but there are two deplorable absences: (1) The absence of truly historical material from some old-established companies, whose officials chose to send us only descriptions of recent outstanding developments: (2) The absence of ANY contributions from certain companies which advertise in *Instruments* and otherwise cultivate the goodwill of *Instruments* readers; the only explanation is that their officials "leaned backward" with extreme modesty. This, too, is an inevitable manifestation of human nature.

Your editor, and The Instruments Publishing Company, Inc., hereby disclaim responsibility for assertions of priority and this disclaimer is supported by the original manuscripts. Careful as we were to preserve wordings when re-writing lengthy descriptions, we were extra-careful in such cases of "firsts": WE DID NOT EDIT SUCH ASSERTIONS AT ALL. Where assertions are made flatly, they are the author's own assertions.

Exaggerations made as flat assertions were not edited. Similarly, when the description of an original model was accompanied by a photograph (of what looks like a modern model but is) PLAINLY MARKED WITH THE YEAR OF THE ORIGINAL, we unquestioningly used this photograph.

Seldom does *Instruments* comply with requests that its "write-ups" be "submitted for approval" before being printed. This time, such requests did not even draw replies.

Many writers included in the description of one specific development numerous explanations of its importance to the design of later developments which were not dated and for which no SPECIFIC descriptions were written. Inexcusable as this was, we studied all these meandering stories and extracted all we could for insertion under later dates.

Most of the raw material as received was—well, terribly raw. To correspond individually with all these writers, returning their contributions and offering suggestions as we do with authors of technical articles, would have meant more than two thousand hours of supplemental editorial work. Special letters asking for essential data such as dates, etc., were sent by an assistant who enclosed copies of the rules. These simple inquiries should have drawn 100% replies; they did not! Many writers must have re-read the rules and said to themselves, "Oh, well, I've made a flop of my stories and it's too late to try to fix them up!" Even then, we did not discard these unusable contributions: we MADE them usable whenever possible! How? That, dear friend, is a secret—which you could have learned if you had dropped in between 1 and 4 a.m. on many a wintry night!

—MFB

JOURNAL of the Instrument Society of America

Editor, R. R. PROCTOR, 2213 Ridge Ave., Evanston, Ill.
I.S.A. National Office, 1117 Wolfendale St., Pittsburgh 12, Penna.

I.S.A. Officers

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Carl F. Kayan, 1st V. Pres. | H. C. Frost, V. Pres. | Richard Rimbach, Exec. Sec'y.
Fred H. Trapnell, V. Pres.

Vol. 3 | March 1948 | No. 3

Editorial

Sequel on Securing Speakers

It is our pleasure to report that definite progress has already been shown in the Society's attempt to organize a (for lack of a better name) Speakers Bureau, or otherwise offer some assistance to the various Sections in their attempts to obtain good speakers. We like to think that our editorial entitled "On Securing Speakers," in the January (1948) issue of the JOURNAL, was influential in some small way in accelerating this project, but whether it was or not, we are glad to see some action being taken.

This so-called "sequel" to the January editorial may be considered more of a Progress Report than an editorial, but this column is probably as good a place for that sort of news as for anything else.

Three pertinent items of news are worthy of passing along at this time, and we hope to have more information to report soon.

The first is the information we have received to the effect that three or four Sections are changing, or are considering changing soon, their meeting nights to fit into the "swing" plan, outlined in the above-mentioned January editorial. Briefly, this allows the scheduling of meetings such that one speaker can "tour" several adjacent Sections on consecutive nights. If and as this plan develops, we may see several distinct "circuits" in the Society, the establishment of which will eventually make it much easier for all Sections in any one "circuit" to obtain good speakers consistently.

The second item of interest is that General Electric Company has provided the I.S.A., as well as other technical and scientific societies, with a list of engineers from the G. E. General Engineering and Consulting Laboratory who have expressed willingness to undertake speaking engagements before technical and engineering groups. The topics listed cover a wide range. Mr. John A. Miller of the G. E. Laboratory, in offering this material, writes that "... We feel that the interchange of engineering information in this way is beneficial all around and are glad to have our engineers give these talks without expense to the local group which invites them. Sometimes, of course, it may be impractical for a particular individual to talk on a particular occasion, but we will do the best we can to comply with any requests that may be received."

Executive Secretary Richard Rimbach has passed along this information, in the form of a mimeographed announcement, to members of the Executive Committee and the Board of Directors. If any Section Director did not receive such a list, he can obtain it from Mr. Rimbach, and can pass it on to the Program Chairman—who will no doubt be glad to get it.

We take this opportunity to express our appreciation to General Electric Company for this very helpful gesture; at the same time we would like to express the hope that other companies will volunteer similar services to the Society so that eventually a very comprehensive list of available speakers and appropriate topics can be on file in the I.S.A. Speakers Bureau.

The third reportable activity is the starting of a speaker "rating" service, proposed by several people in times past and finally crystallized by Secretary Rimbach in January. Mr. Rimbach has prepared a tentative layout of a form on which it is proposed that some designated individual at a Section meeting should appraise the speaker carefully on his delivery, poise, voice, subject matter, visual aids used, etc., as well as what the Section itself provided for the speaker. This anonymous individual would then send his rating in to the Speakers Bureau or other designated party or committee for evaluation.

(This preliminary form has been sent to all members of the Executive Committee and the Board of Directors for comments, corrections, suggestions, etc., and many of the Directors have circulated their copies to Section officers and others for their opinions and suggestions. The final form, as being prepared by Mr. Rimbach, thus will contain the best of the ideas of many people and should make it possible for each Section to prepare a very comprehensive, but confidential, appraisal of each speaker appearing before that group.)

A few such reports in the hands of the Speakers Bureau will soon automatically pick out the outstanding speakers in the measurement and control (or allied) fields, and bring into being a very useful phase of the suggested Speakers Bureau, Program Service, or whatever it eventually chooses to be called.

It takes a long time to put such a many-faceted program into operation, but the groundwork has been laid and progress is being made. It shouldn't be too long now.

We just thought you'd like to know.

—RRP

Editor's Notes

1. Errata

It is with considerable regret we learn that two typographical errors occurred in the printing of Dr. C. J. Overbeck's paper "Fundamentals of Radioactivity" which appeared in the January, 1948, issue of the JOURNAL. The errors both occurred in the same paragraph, and the correction is as follows:

Paragraph 2 of column 2, page 85, should read—

"Since one electron volt energy is 1.6×10^{-12} ergs, the energy in ergs of the two resulting α particles must be
$17 \times 10^6 \times 1.6 \times 10^{-12} = 27.2 \times 10^{-6}$ ergs
The right hand side of the equation gives
$3.05 \times 10^{-26} \times (9 \times 10^{10})^2 =$
27.45×10^{-6} ergs
The balance tallies . . . etc."

3. The Needle Points to—

Chicago, Louisville, Northern Indiana, and Oak Ridge for very excellent reports of Section activities.

4. Rochester Granted Charter

We have just learned that by action of the Executive Committee, a charter has been issued to the Rochester Section of the Instrument Society of America. The date of issue was February 16, 1948.

We take this opportunity to welcome the Rochester group—our 35th Section—and to wish them success. Until we can publish the names of Rochester's Secretary, Director and JOURNAL Correspondent in our "To All Section Secretaries" column (probably in the next issue), correspondence with that group will be handled by Mr. Ralph C. Schwarz, Jr., 1201 Granite Building, Rochester 4, N. Y.

—R. R. Proctor

General News

Notes on New York Conference Jan. 30-31

The Semi-Annual I.S.A. Conference held at the Pennsylvania Hotel, New York City, January 30 and 31, 1948, at which the New York Section was host, attracted approximately 500 registrants, according to Norman J. Cherry, chairman of the registration committee. The general theme of the Conference was The Application of Electrical Elements in Industrial Instrumentation.

Technical Sessions

Technical sessions on Friday morning and Friday afternoon, January 30, were held in the Georgian Room of the Hotel Pennsylvania. The Saturday, January 31, morning session was held in the Penn Top room, and the Saturday afternoon session at Columbia University.

The Friday morning session consisted of papers on Thermistors, Thyrite Resistors, Germanium and Silicon Rectifiers, and Humidity Sensing Elements, presented by (respectively) J. E. Tweeddale of Western Electric Company, E. J. Allen of General Electric Company, E. H. Ulm of Sylvania Electric Company and W. F. Hickes of Foxboro Company. Harry F. Moore (New Jersey Section), of Standard Oil Development Company, acted as Technical Chairman.

The Friday afternoon session, under the chairmanship of H. L. Hildenbrand, President of the New York Section, consisted of papers on Strain Gages, Light Sensitive Cells, and Electrolytic Conductivity Cells, presented by (respectively) C. H. Gibbons, Baldwin-Southwark Division, A. T. Williams of Weston Electrical Instrument Corporation, and Robert Rosenthal, Industrial Instruments Corporation.

The Saturday morning session, chaired by Prof. Carl F. Kayan of Columbia University, was a double-barrelled "Survey of

I.S.A. Regional Meeting and Dinner at the Pennsylvania Hotel, January 30, 1948.

Electrical Recording Instruments" featuring Perry Borden of the Bristol Company and C. O. Fairchild, Consultant and Past President of the I.S.A. Mr. Borden, with the aid of many slides, described the development of recording instruments of all types up to the present time. Mr. Fairchild, taking over at this point and with aid of more slides and a selection of modern recorders and controllers of various makes, described the operating principles of most of the present-day instruments.

The Saturday afternoon session was held at Schermerhorn Hall, Columbia University. The speakers, introduced by Professor Kayan, were Prof. J. B. Russell of Columbia University, who spoke on "Electronic Techniques in Continuous Type Computers," and Prof. W. J. Eckert of Columbia University, whose subject was "Digital Computing Devices and Application to the Solution of Technical Problems." Methods of setting up the equations, and in turn the computing instruments, to solve certain complex problems were explained, and the afternoon was topped off by a tour through the Watson Scientific Computing Laboratories at Columbia University.

Instrument Short Course

Two educational sessions were conducted on Saturday, January 31, in the Georgian Room, Hotel Pennsylvania. Speakers were (Chairman) E. R. Manning, Weston Electrical Instrument Corporation; H. O. Nilsson, Nilsson Electrical Laboratories; Chas. E. Haggerty, New York City Department of Public Works; and W. A. Shedlock, Sperry Gyroscope Company. On the general subject of Servicing the Permanent Magnet Moving Coil Instrument, the discussions centered about application and installation techniques, examination, tools and equipment, repairs, electrical calibration procedures, and a discussion of principles, circuits, etc.

Banquet

A dinner meeting was held Friday evening, with well over 100 in attendance. President Hildenbrand of the New York Section presided, introducing the national officers and acting as master of ceremonies. During his announcement of the election of new officers for the New York Section, Mr. Hildenbrand was presented with a fine leather traveling kit, equipped with silver accessories, by Professor Kayan on behalf of the New York Section membership.

Several prizes were given to those who qualified under the following circumstances:

The person who came from the greatest distance. (Won by Mr. Long, Shell Development Co., San Francisco, Calif.)

The youngest person present. (Won by Mr. Carter, Winthrop Chemical Corp. Age 23.)

The oldest person present. (Won by H. H. St. Clair, Hart Moisture Gages. Age 69.)

National Executive Secretary Richard Rimbach then reported on the status of the membership. His records show a membership of 2750, with 34 Sections active, and he reported that two more groups were soon to petition for charters (Montreal with approximately 90 members and Rochester, N. Y., with approximately 110).

After thanking Mr. C. H. Colvin, Conference Chairman, and the various committees for their excellent efforts in arranging the Conference, Mr. Hildenbrand turned the meeting over to Ralph R. Batcher, Executive Editor of Electronic Industries and newly-elected President of the New York Section, who gave a demonstration lecture entitled "Electronic Fantasies." His talk combined the historical background of cathode ray tubes with interesting exhibits of what could be done with the modern oscilloscope. Although equipment failure prevented his demonstrating some of the principles he described, the audience participation in voice pattern demonstrations and his post-meeting demonstration of the lie detector made the meeting very interesting.

Executive Committee Meeting

A meeting of the national Executive Committee was held in installments during the Conference, and the minutes of this meeting will be abstracted and reported in the next issue of the JOURNAL.

Detroit Section Sponsoring Basic Instrumentation Course

At the request of the Detroit Section of the Instrument Society of America, the University of Michigan Extension Service and the College of Engineering are offering a noncredit course on the underlying principles of temperature, pressure, flow, and liquid level, and on the typical instruments used in their measurement and control.

The sixteen lectures and discussions will cover the following general topics:

Standards: Discussion of the physical standards upon which all measurements are based and the reference instruments used in the typical laboratory.

Pressure Gauges: The basic types of pressure measurement and the typical instruments used.

Temperature: A discussion of the measurement of temperature by means of bimetallic strips and discussion of the expansion type, pressure actuated, and indicating and recording thermometers.

Pyrometry: Five lectures on the use of the resistance thermometer, and thermoelectric, optical and total radiation pyrometers.

Flow Meters: A discussion of inferential and volumetric and current types of flow meters used for measuring the quantity of fluid flowing in a closed circuit.

Liquid Level Measurement: Discussion of the principal types of liquid level instruments, including visual, float-actuated, electrical contact, static pressure, and pressure differential types.

Instructors for the course are Frank W. Sowa, William C. Truckenmiller and Joseph J. Martin, all of the staff of the College of Engineering. Classes are held in the Rackham Educational Memorial at 7:00 p.m. on Fridays, starting with February 13th. Registration fee is $15.

Other courses in engineering subjects are scheduled for the spring, detailed information about which will be sent on request. All inquiries should be addressed to the University of Michigan Extension Service, Horace H. Rackham Educational Memorial, 60 Farnsworth, Detroit.

Official News

To All Section Secretaries

The following changes and additions should be made in the list of Section Secretaries, Directors and JOURNAL Correspondents published in the December issue of the JOURNAL:

BALTIMORE—Change of address of Secretary: Felix O. Cox, Jr., 2903 Dunmore Road, Baltimore 22, Md.

CALIFORNIA—New Secretary and JOURNAL Correspondent: D. Dwight Taylor, 234 East Colorado St., Pasadena 1, California.

CHARLESTON—New Secretary: W. E. Warner, Route 3, Box 274, Charleston, W. Va. (Address not given last time.) New JOURNAL Correspondent: Miss Mary K. Adams, 1510 Lee Street, Charleston 1, W. Va.

GULF COAST—New JOURNAL Correspondent: R. M. Brent, Route 2, Box 98-F, Port Arthur, Texas.

LOUISVILLE—New Secretary: Paul R. Smith, c/o Joseph E. Seagram & Sons, Inc., Seventh Street Road, Louisville, Ky.

NEW YORK—New Secretary and JOURNAL Correspondent: Charles E. Haggerty, 7552 181st St., Flushing, L. I., New York. New Director: Ralph R. Batcher, c/o Electronic Industries, 480 Lexington Ave., New York 17, N. Y.

NIAGARA FRONTIER—New JOURNAL Correspondent: W. J. Sommers, 505 Delaware Ave., Buffalo, N. Y.

Changes in Meeting Date Chart

In the January issue of the JOURNAL on the editorial page, a chart of regular meeting dates of the various Sections was published. Since its publication, the Editorial office has been advised of some changes which are listed herewith for the benefit of Section Program Chairmen or other Section officials who may be relying on the chart for assistance in timing or scheduling their own programs.

Add CALIFORNIA, first Tuesday each month.

Add PRESQUE ISLE, fourth Tuesday each month.

Change BALTIMORE from first Friday to second Friday.

Change KANSAS CITY from fourth Tuesday to last Tuesday.

With only two blanks remaining in the chart (Gulf Coast and New Orleans), and with only one new Section to be added as of this writing (Richland), the chart is as complete and up-to-date as it has been possible to make it. Attempts are being made to obtain the proper information from Gulf Coast and New Orleans, and Richland will forward its information as soon as a regular meeting date has been established.

The Editor will appreciate notification of any other changes which should be made in the chart in order that all Sections may be kept correctly informed through the medium of the JOURNAL.

Special Report from Committee on Committees

Just one year ago (March, 1947) the special "Committee on Committees," under the chairmanship of W. A. "Bill" Wildhack (now President of the Washington Section), submitted to the Executive Committee a report concerning the duties of each of the standing committees of the Society. The rules and duties outlined in that report were prepared with such thoughtfulness and foresight that hardly any changes were required to make it an immediately workable plan on which the present committee structure of the Society is based.

Many requests have been received to publish this report in the JOURNAL. At the January 29th meeting of the Executive Committee in New York, its publication was approved, and it is presented herewith:

ISA Committees

1. Executive Committee. (The powers of this Committee are granted broadly by the Constitution. It would be desirable to have a fairly specific listing of the methods whereby this Committee "carries out the policies determined by the Board," and to have its rules of conduct formulated and on record, but the preliminary drafting may best be left to the officers.)

2. Advisory Council. The membership of the Advisory Council shall be broadly representative of science, industry, education and government. The members of the council shall consider how the maximum contribution of the Society to these aspects of civilization may be realized, shall recommend desirable activities for the Society, and shall advise the officers upon request on specific questions of general policy.

3. Instrument Manufacturers' Advisory Committee. The Instrument Manufacturers' Advisory Committee shall be representative of the instrument manufacturing industry and its various trade associations. The members of the Committee shall advise the officers of the Society, as requested, upon questions of policy relating to the industry, and on methods whereby the Society can best contribute to the solution of problems of training, placement, public information, standardization and technical research, to the mutual benefit of the industry and the Society.

4. Constitution, By-Laws Committee. The Constitution and By-Laws Committee shall receive and initiate proposals for changes in the Constitution and By-Laws of the Society, and shall cooperate with initiating groups or individuals in drafting the proposed amendments, and shall submit a report to the Board of Directors, with recommendations, on each proposed amendment formally submitted.

This Committee shall also formulate, coordinate, maintain records of, and periodically review such rules and procedures as are deemed necessary or desirable and are promulgated or approved by the Board of Directors for the guidance of officers and members of the Society, in the conduct of the Society's activities, and in facilitating fruitful contacts and cooperation among themselves and with other technical societies. Rules adopted by any Committee for the conduct of its own activities, or directives for its sub-committees, shall be referred concurrently to the Committee on Rules and Procedures for comment and recommendations and to the Board of Directors for approval.

5. Coordinating Committee. The Coordinating Committee shall study the activities of other scientific and technical societies, trade associations, commissions or other groups concerned with technology, and make recommendations to the Board of Directors for possible specific programs of cooperation with such groups in furtherance of common objectives, and shall coordinate the activities of other committees involved in carrying out such cooperative programs as directed by the Board of Directors.

(Members of the Society designated as representatives of the Society to other organizations should be ex-officio members of the Coordinating Committee.)

6. Educational Committee. The Educational Committee shall study and report on the extent and quality of specialized education in the theory and use of instruments available through educational institutions, apprentice programs, correspondence courses, or in-training programs in industrial, government and research foundation laboratories; and prepare recommendations to the Board of Directors as to specific changes considered desirable, and as to specific programs of direct or cooperative action of the Society in educational programs, and shall, as directed, carry on such programs.

7. Employment Committee. The Employment Committee shall actively facilitate the placement of qualified workers in any phase of instrumentation.

8. Finance Committee. The Finance Committee shall make recommendations to the Executive Committee or the Board of Directors on any proposed changes in the budget and on investment of surplus funds; shall study and recommend financial policies and report on trends in income and expenditures; and shall propose an annual budget, based on estimates of the officers and committees, available funds and expected income, and submit it to the Board of Directors at the Annual Meeting.

9. Meetings Committee. The Meetings Committee shall recommend the place and date for the Annual Meeting and Exhibit, and for all other national, technical or membership meetings sponsord by the Society. It shall have the primary responsibility for all arrangements for these meetings.

10. Membership Committee. The Membership Committee shall prepare literature describing the activities of the Society and citing the advantages of membership, arrange for circulation of such literature to persons in instrumentation and allied fields, and shall study, compare and report on various methods of attracting qualified applicants for membership. When requested by the Board of Directors or the President, it shall provide advice to Sections on methods of attracting members, arrange for receiving membership applications at meetings, conduct surveys to determine the views, desires, or suggestions to the membership on proposed membership services or other activities of the Society, prepare analyses of membership statistics, and submit reports and recommendations on problems of membership interest.

11. Nominating Committee. The Nominating Committee shall solicit and receive suggestions for nominees for the elective officers of the Society, and shall submit a report to the Board of Directors at least 60 days prior to the Annual Meeting, recommending at least two nominees for each regular vacancy. It shall recommend election procedures and arrange for elections as directed by the Board of Directors.

12. Publications Committee. The Publications Committee shall study and recommend publication policies, and shall publish transactions, reports, journals, pamphlets, and books as authorized by the Board of Directors.

13. Recommended Practices Committee. The Recommended Practices Committee shall study technical practices in instrumentation and prepare and recommend uniform practices where adoption of such uniformity would simplify work or facilitate general understanding and interchange of information, and promote their general adoption.

14. Research Committee. The Research Committee shall initiate, receive, and consider proposals for research and development in any phase of instrumentation, and shall recommend such proposals as it deems desirable to the Board of Directors for adoption. As directed by the Board of Directors, it shall cooperate in such research projects with educational and governmental research institutions, industrial organizations, or other technical societies.

15. Sections Committee. The Sections Committee shall aid and sponsor the formation of new Sections of the Society, and when requested shall aid the officers of any Section in improving the effectiveness of the Section.

Special Committee

16. Committee on Committees. This committee shall initiate and receive suggestions for the establishment of new standing committees, for addition or modification of duties, scope, or activities of existing committees, and shall recommend to the Board of Directors and the Constitution and By-Laws Committee such changes in the By-Laws as may be necessary to provide for the committees required to carry on the proper and desirable activities of the Society.

Proposed New Committee

17. Committee on Rules and Procedures. This committee shall formulate, coordinate, maintain records of, and periodically review such rules and procedures as are deemed necessary or desirable and are promulgated or approved by the Board of Directors for the guidance of officers and members of the Society, in the conduct of the Society's activities, and in facilitating fruitful contacts and cooperation among themselves and with other technical societies. Rules adopted by any Committee for the conduct of its own activities, or directives for its sub-committees, shall be referred concurrently to the Committee on Rules and Procedures for comment and recommendations and to the Board of Directors for approval.

Meetings Committee Reports On Philadelphia Conference

A report on the progress of arrangements for the 1948 Conference and Exhibit to be held in Philadelphia in September has been submitted in the form of a letter from E. J. Grace, Chairman, to President Paul Exline. This letter, dated January 22, 1948, is abstracted herewith:

Analog Program (Chairman Paul Hoell). Such a program is being considered and a report will be made (later) by the Chairman.

Banquet (Chairman William G. Gallagher): The exact form of this function is being considered by the committee and the Chairman will report. Whatever this meal function, it will be held on Wednesday evening (Sept. 15) and will include all participating societies.

Breakfasts: A press breakfast will be arranged on Monday morning. Speakers' breakfasts will be arranged each morning. The possibility of arranging an "Early Bird's" breakfast . . . daily beginning Tuesday . . . has been discussed.

Education Program (Chairman A. Adler): This program will be similar to that of previous years.

Exhibit: A separate report on this has been prepared by Secretary Rimbach. At the end of the (first) 30-day period, 115 booths of a total of 200 were sold. The Exhibit will be open three evenings.

Historical Exhibit (Chairman R. Werey): No report at this time.

Luncheons: The participating societies will probably arrange luncheons. A Section Secretaries' luncheon is again planned.

Movies (Chairman A. Adler): A continuous program of movies on instruments will be arranged.

Panel Discussion: A program for instrument men concerned with instrument department practices and organization has been discussed.

Technical Program (Chairman Lyman Allen): The technical program is progressing very well. Two evening sessions have been arranged. A list of the speakers and titles of their papers will be issued shortly. The morning sessions will start at 10:00 a. m.

Separate reports will cover activities of participating societies and of the Publicity Committee. E. J. Grace, *Chairman.*

Section News

BALTIMORE

The February meeting of the Baltimore Section was called to order at 8:30 p.m. on Friday, February 6th, at the Baltimore Engineers Club, by President Howard L. Halstead. Some 100 members and guests were present.

We were particularly fortunate in having Messrs. R. N. Pond and J. F. Barnum, both of Taylor Instrument Companies, to present a lecture and demonstration on "Principles of Automatic Control." The lecture began with a "fairy tale" in which many of the common faults in automatic control installations were outlined. Proceeding with the demonstration, solutions to many problems were shown using a complete pneumatic control installation including devices to represent lags, capacities, etc. The effect of throttling range, reset and preset settings on various processes were explained and clearly shown on a three-foot strip chart recorder.

The success of the demonstration was apparent from the spontaneous applause awarded Messrs. Pond and Barnum.

Our regular meeting night has been changed from the first to the second Friday of each month. The March 12th meeting will feature Dr. T. L. Smith of Aberdeen Proving Grounds who will speak on "Wind Tunnel Instruments."

—Felix O. Cox, Jr., *Sec'y.*

CALIFORNIA

The February meeting of the California Section was held on Tuesday, Feb. 3, at the Pasadena Athletic Club. The general subject of the meeting was "Die Casting." A color-sound movie bearing this title was presented through the courtesy and cooperation of Morris P. Kirk & Son and the New Jersey Zinc Company. Mr. L. Larrieu, Chief Chemist for Morris P. Kirk & Son, was the speaker.

I.S.A. CALENDAR OF EVENTS

Section	Date of Next Meeting	Type	Place	Speaker	Subject
Baltimore	4/9/48	M8	Baltimore Eng. Club	Speaker from Automatic Temperature Control Co.	To be announced
Central Indiana	4/6/48	MX	Purdue Ext. Center	J. Stewart, Bristol Co.	"Telemetering"
Charleston	4/5/48	DX8	Kanawha Hotel	H. H. Barnum, H. H. Barnum Co.	"Human Instrumentation"
Chicago	4/5/48	DX8	Builders Club	R. J. Kryter, Esterline-Angus Co.	"Atomic Energy"
Cleveland	4/28/48	DX8	Cleveland Eng. Soc.	D. P. Eckman, Conoflow Corp.	"Force Balance Systems Applied to Weight Measurements"
Cumberland	3/23/48	DX8	Algonquin Hotel	R. R. Webster	"Supersonic Testing of Steel"
Detroit	4/20/48	M8	Rackham Bldg.	Lyle E. Eige, Fisher Governor Co.	"Fundamental Principles of Self-Operated Controllers"
Kansas City	3/30/48	D6X	Crossroads Restaurant	W. H. Pugsley, Hays Corp.	"Electronic Measurement and Control"
New Jersey	4/6/48	D68	Essex House, Newark	Forum	"The Instrument Doctors Disagree"
Niagara Frontier	3/22/48	M8	N.Y.Inst.Appl.Arts & Sci.	Dr. J. A. Bergantz, Buffalo Electrochemical Co.	"Instrument Control in the Manhattan Project"
Niagara Frontier	4/26/48	M8	N.Y.Inst.Appl.Arts & Sci.		Business meeting—election of officers
Northern Indiana	4/21/48	D78	Lake Hotel, Gary	Wm. H. Pugsley, Hays Corp.	"Combustion Control"
Philadelphia	3/17/48	D68	Penn-Sheraton Hotel	L. H. Allen, R. L. Hurley	Member-Audience Participation Program on "Instrument Terminology"
St. Louis	4/7/48	DX8	Engineers Club	Ed. Dahl, Hammel-Dahl Co.	"Automatic Control Principles"
Sarnia	3/19/48	M8	Moose Hall	L. Guess, Brown Instr. Co.	"Flow" plus film on "Hydraulics"
Southern Michigan	4/21/48	DX8	Chicken Charlie's, Kalamazoo	Lyle E. Eige, Fisher Governor Co.	"Fundamental Principles of Self-Operated Controllers"
South Bend	4/1/48	DXX	Eng.Bldg.Univ.Notre Dame	Henry Schmidt, Brown Instr. Co.	"Low Range Radiamatic Instruments"
Tulsa	4/5/48	MX		Ed. Dahl, Hammel-Dahl Co.	To be announced
Twin Cities	4/26/48	DXX	Univ. of Minn. Coffman Mem. Un.	J. B. McMahon, Republic Flowmeters Co.	"A Non-Mathematical Discussion of Flow Measurement"
Wayne County	4/19/48	DX8	St. John's Ev. Church, Wyandotte	Wm. H. Pugsley, Hays Corp.	"Electrical Instruments for Measurement of Process Variables"

LEGEND: Meeting only, no dinner—M7, MX or M8 (7 pm, 7:30 pm or 8 pm respectively) Dinner meeting—first symbol D; second symbol time of dinner (6 for 6 pm, X for 6:30 pm, 7 for 7 pm); third symbol time of meeting (7 for 7 pm, X for 7:30 pm, 8 for 8 pm).

The new officers of the Section for the year 1948 are:

President—Arnold O. Beckman, National Technical Laboratories.
Vice-President—Walter Bach, Berndt-Bach, Inc.
Treasurer—Cedric Sjoberg, Santa Monica.
Secretary—D. Dwight Taylor, Consulting Physicist, 284 E. Colorado, Pasadena 1, Calif.

Meetings of the California Section are to be held on the first Tuesday of each month except July and August, with dinner at 6:45 p.m. and the technical session at 7:45. Because of the wide geographical distribution of the membership, the meetings are divided betwen Los Angeles and Pasadena.

—D. Dwight Taylor, *Sec'y.*

CHARLESTON

Mr. J. B. McMahon, Chairman of the I.S.A. Sections Committee and a past Vice-President, honored the local members with an interesting evening February 2, 1948. After a dinner in the Hotel Kanawha dining room, the group adjourned to the meeting room where President L. F. Keppler introduced the speaker.

Mr. McMahon told of his experiences while in England last spring as a representative of his company, Republic Flowmeters. Comparison of conditions, attitudes, production rates, and actual products with those of this country were the most salient features of his talk.

—Mary K. Adams, *Corr.*

CHICAGO

The 1948 half of the current series of Chicago Section programs were successfully launched on January 5th with a very interesting talk by Albert F. (Al) Sperry and a very good dinner by Phil Smidt at Roby, Ind.

Al's official, scheduled and prepared talk was preceded by an unofficial but extremely interesting session concerned with just what constitutes an automatic controller and just what is a servomechanism. Al demonstrated the difficulty of defining the two devices concisely by producing a dozen or more different official definitions of each, nearly all of which could be interpreted in such a way as to apply to either device. He pointed out, however, that there is a definite recent trend toward a more restrictive classification in which the constant load-variable input devices would be defined as servomechanisms, whereas the variable load-constant output devices would be defined as automatic controllers.

In his formal, prepared talk on "Servomechanisms," Al gave a novel explanation of the purpose and function of each of the several types of control responses used in present industrial instruments.

Most of us who attended the meeting of February 2nd were astounded to learn of the complexity of the railroad signaling equipment which keeps a constant vigil over our safety as we speed along the rails. Mr. G. W. Baughman, Chief Engineer of the Union Switch and Signal Company, did an excellent job of handling a subject of such wide scope. His subject was "Instrument Applications in Railroad Signaling."

After the showing of a film called "Railroadin' ", which provided the proper railroad atmosphere, Mr. Baughman described briefly the principles involved in signal systems. With the aid of illustrative slides, he described the relays and other component parts which are used in the system. The duties of a train dispatcher and the panel full of instruments and controls at his disposal were described by the speaker. He explained how numerous signals are transmitted over a single pair of conductors, how certain messages are given priority, and how the switching and timing of train arrival is arranged.

Following Mr. Baughman's talk, the usual discussion period proved particularly interesting. The interest shown during this period clearly illustrated that although this paper was not devoted strictly to instrumentation, it was very appropriate for presentation to an instrument-minded group.

—J. N. Swarr, D. S. Dickey

CLEVELAND

On January 28th, eighty members and guests of the Cleveland Section gathered at the Cleveland Engineering Society to hear Mr. Paul Wing, Jr., of Mason-Neilan Regulator Company, give a most interesting and educational talk on "Displacement and Ball Float Level Controllers." The meeting was preceded by an excellent dinner which was also well-attended.

The February 25th meeting will feature Mr. V. V. Tivy, Sales Manager of the Oil and Gas Division of the Foxboro Company, who will speak on "Instrument Applications in the Process Industries."

—L. H. Waldrip, *Corr.*

CUMBERLAND

The Cumberland Section held its regular monthly dinner-meeting Tuesday, January 27th, at the Hotel Algonquin.

The speaker for the evening was Mr. J. B. McMahon. Mr. McMahon needs no introduction to members of the Instrument Society of America.

His talk was entitled "Experiences of a I.S.A. Man Abroad." It was a very interesting talk and was highly informative for those who have often wondered how American Industry compares with that of Great Britain both before and after the Second World War. A very good selection of slides rounded out his formal talk.

After several questions were answered concerning his talk, one question was put before him which concerned the instrument field. "What are the qualifications for the various classifications of Instrument Mechanic?" We learned that Mr. McMahon has been and is working for such standards to be set up for the Instrument Industry whereby the various classes of Instrument Mechanics would be recognized throughout the country according to their classification. He pointed out that we need a uniform educational program in order to accomplish such a task.

He impressed upon us that such a program would require quite a bit of work and backing. The Cumberland Section is ready and willing to back such a program.

—G. William Harrison, *Corr.*

EASTERN NEW YORK

In the absence of President J. P. Smith, the February 3rd meeting was conducted by Secretary W. J. Claffie. The meeting was opened at 8:00 p.m. and Mr. J. M. Maitland was asked to give a brief resume of the Regional Conference held in New York City the previous weekend. Mr. Maitland commented very favorably on the meeting, giving a description of events for the benefit of those who were unable to attend.

It was announced that the Eastern New York Section had recently become a member society of the Schenectady Engineering Council. Following a few other announcements dealing with the Section activities, the meeting was turned over to the speaker of the evening—W. W. Matlack.

Mr. Matlack, who is Vice-President of the Section, spoke on "Automatic Temperature Measurement and Control." This talk was split into five parts dealing with the instruments and controls, how and why they work, as manufactured by the Minneapolis-

(Continued on page 279)

Some Problems of Application of Conductivity Equipment *

By A. L. CHAPLIN, Consulting Engineer, Oreland, Pennsylvania.

A non-mathematical review of equipment problems as affected by application requirements.

THE preceding papers (of this Conference session) have dealt with *concentration* instruments of a type which respond to certain characteristics of *specific ions* or the effects of total *molecular* aggregation (viz., polarography and viscosity measurements). This paper covers some problems of application of a concentration instrument which responds to *total* ion concentration and does not distinguish between generic origins of ions measured. It is used to evaluate total molecular concentration indirectly by measurement of total ion concentration and is limited in application to electrolytes which conduct the electric current.**

The mechanism of electrolytic conductivity is by ion migration, which, in turn, varies as a function of concentration, temperature and the ion type. Holding other variables constant, or otherwise compensated, the device becomes useful as a tool to measure any one variable. As a concentration tool the instrument is limited by differences in mobilities of ion pairs and their concentration because of their

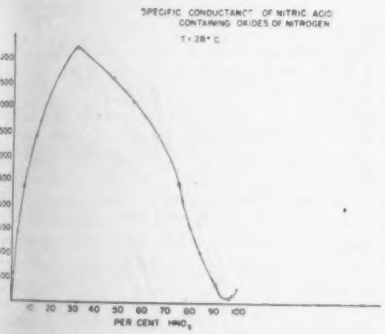

Fig. 1

tendency to accumulate at the electrode interface and thus introduce polarization error effects. The higher the concentration and the greater the difference in mobility of ion pairs, the greater is the tendency to polarize.

The Author

After graduating from West Virginia University with a B.S. degree in Chemical Engineering, Allen L. Chaplin worked for several years in the chemical industries as chemical engineer, then returned to WVU and received an M.S. degree in Physical Chemistry and Physics in 1936. In 1935 he was associated with the Department of Agriculture in Charleston,, W. Va., as Chemical Engineer. In 1937 he joined Leeds & Northrup Company, with whom he served as Application Engineer until 1945. From 1945 to 1947 he was Process Control Engineer for American Cyanamid Company, and from March to July of 1947 worked with Kellex Corporation on guided missile research at the Applied Physics Laboratories of Johns Hopkins University. The balance of 1947 was spent as an Engineer with Askania Regulator Company. He is now a Consulting Engineer, and resides at Oreland, Pennsylvania.

This effect is minimized by the use of alternating currents at a frequency depending on concentration range and accuracy requirements. The greater the concentration, the higher must be the frequency to cover a given rangeability with a given accuracy. Frequencies of 1000 cps or above are used for laboratory measurements requiring accuracies of 0.1% to 0.01% or better, while the more convenient power frequency of 60 cps is used for industrial applications requiring accuracies no greater than 1.0%. The error introduced by reducing the frequency below 1000 cps varies empirically as the inverse of the square root of the frequency ratio.

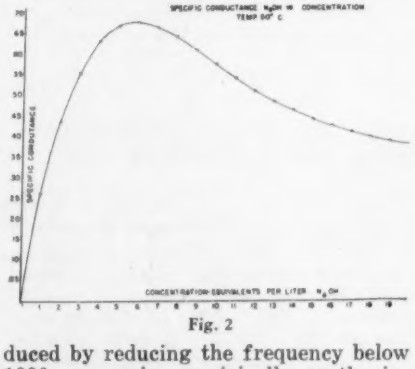

Fig. 2

The resistance characteristic of conducting *ions* in aqueous solution is linear with respect to concentration. While this is a desirable attribute of scale calibration, the measurement of total ion concentration *per se* has limited practical value since the instrument is usually applied to evaluate total molecular concentration.

The degree of ionic dissociation of an electrolyte varies nonlinearly with concentration and the resultant resistance characteristic is nonlinear. It is not uni-directional except over small ranges of concentration.

Fig. 1 is a plot of specific conductance characteristics of nitric acid containing oxides of nitrogen. The effect of these oxides is to alter the molecular structure of the acid and its resultant resistance characteristic. It is obvious that the rangeability of an instrument for this application would have limited coverage. It would not be feasible to build an instrument covering the entire concentration range, and it is necessary, as a practical expedient, to divide the scale to cover limited portions of the characteristic which are uni-directional although calibration will be nonlinear.

Fig. 2 shows similar variations in specific conductance with total molecular concentration of a strong base, sodium hydroxide. This electrolyte bears striking resemblance to the nitric acid curve in passing through a maximum, but differs by approaching an asymptotic limit at high concentrations rather than passing through a minimum.

Sulphuric acid has a resistance-concentration characteristic similar to nitric acid and exhibits a maximum and minimum at corresponding concentrations and a second maximum at a relatively higher concentration, Fig. 3. Each and every electrolyte has its own specific conductance-concentration characteristic and must be analyzed independently.

An important problem in the steel industry has been the determination of recoverable iron lost in spent pickle acids. Conductivity methods have been tried but have not proved entirely satisfactory. The problem is presented here to illustrate the relative complexity of evaluating by conductivity methods the molecular concentration of one constituent of a multiple-constituent electrolyte.

Fig. 4 is a resistance characteristic of sulphuric acid over a limited concentration range. The characteristic of ferrous sulphate over a limited range in sulphuric acid of fixed concentration

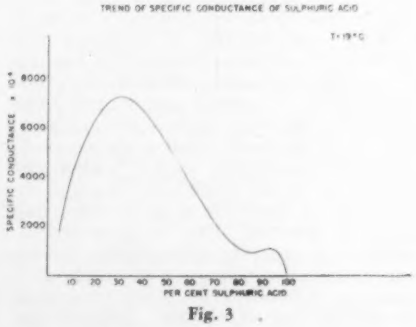

Fig. 3

* Presented at the Second Annual Conference of the Instrument Society of America, Stevens Hotel, Chicago, Ill., Sept. 8-12, 1947.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

** Author's Note: Terminology, as used in this paper, is comparable with the standards pertaining to resistance measurements. Conductance is an inverse function of resistance and definitions are synonymous. Unit resistance is *resistivity* or *specific resistance*. Likewise, unit conductance is *conductivity* or *specific conductance*.

**Although conductivity instruments are limited directly to conducting electrolytes, they may be used to measure, indirectly, the concentration of suspensions of clay, starch or pulp fibers, etc., provided the suspending electrolyte is of constant ionic concentration or is otherwise compensated. The mechanism of such measurements of inert suspensions is the effect of increasing the apparent cell constant by increasing the resistance path, and the method becomes much more effective with increasing weight ratios of the suspended material.

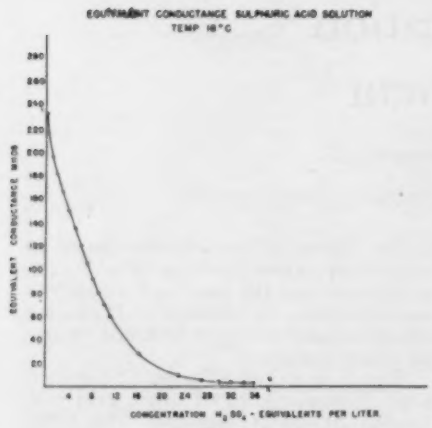
EQUIVALENT CONDUCTANCE SULPHURIC ACID SOLUTION
TEMP 18°C
EQUIVALENT CONDUCTANCE MHOS
CONCENTRATION H_2SO_4 - EQUIVALENTS PER LITER

Fig. 4

is given in Fig. 5. This characteristic is valid only so long as the acid strength remains fixed, and will be upset by any condition which disturbs the common ion ratio. Conductivity responds to changes either in sulphuric acid or ferrous sulphate (or any other conducting additive) and cannot distinguish in itself between constituents unless all variables except one are fixed.

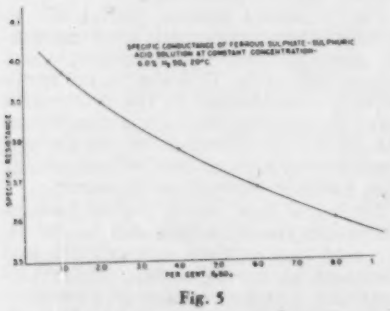

Fig. 5

Some attempts have been made to overcome this by incorporating in a single cell, methods of compensation for variable effects of salt build-up. Specific gravity of the solution varies as a function of all additive constituents while the common sulphate ion of the salt suppresses ionization of the acid, and vice versa. A cell having one fixed electrode and one variable electrode attached to a hydrometer float changes its constant with variations in total electrolyte concentration and thus can be made to act in the direction of compensation for changing acid concentration. This method, while unique, has not found wide application.

In general, conductivity methods must be calibrated for specific conditions of application involving multiple-constituent electrolytes. It is possible to calculate, with good precision, the concentration-resistance characteristics of a single electrolyte in solution but multiple constituent electrolytes cannot be readily evaluated theoretically. The data must be derived empirically. The process must be analyzed and calibration data derived from tests made to establish conditions under which the equipment must operate. Fig. 6 is an example of how these data were and must be derived. This applies specifically to a caustic regeneration process but illustrates the general method of reducing concentration data to specific resistance, which, in turn, is converted to measured resistance by equating it with the cell constant K, in accordance with the equation.

$$R = Kr \qquad (1)$$

where R is measured resistance and r specific resistance.

It is important to note in Fig. 6 the relatively small change of composite specific resistance with changes of causticity. This is due to buffering action of carbonate which limits the sensitivity of conductivity methods for this, or similar application.

Industrial process liquors of indefinite nature must be calibrated empirically. Certain applications such as checking purity of distilled water, sulphuric acid strength, caustic strength and leakage detection are sufficiently well standardized so that instruments with fixed calibrations can be stocked as standard catalog items.

The Cell Constant

Many factors affect solution conductivity and must be accounted for in evaluating this method for a given application. Some of these factors are briefly discussed herein to acquaint the application engineer with their behavior. They are not treated independently at length because of space limitations but are included under the general section of cell constant and polarization, since variations in conditions of operation of a given installation resulting from these effects make their appearance to the plant instrument engineer as polarization errors or as apparent changes in cell constant.

The specific conductance of an electrolyte is defined as the reciprocal resistance of a solution contained between two electrodes, each having 1 sq. cm. cross-sectional area and spaced 1 cm. apart. This is an exact dimension and quite difficult to obtain with production line techniques. As a practical expedient, therefore, it is necessary to evaluate the actual cell constant by either of two procedures.

1. The actual electrode spacing must be measured with a precision of 0.001 cm. or better at the temperature of operation if the cell is to be used for precision measurement requiring 0.1% to 0.01% accuracy. The ratio of l/a becomes the cell constant—a value by which the measured resistance (R) must be divided to convert it to specific resistance (r). (Specific resistance in ohms-cm^{-1} is the reciprocal of specific conductance (c) in mhos-cm^{-1}).

$$R = r\frac{l}{a} \qquad (2)$$

l is the electrode spacing in centimeters and a their cross-sectional area.

2. The technique of measuring actual spacing of electrodes becomes quite involved and unreliable, especially when the electrode surfaces are not parallel and the glass walls of the cell are not of uniform thickness, thus distorting a cathetometer light beam. Furthermore, the true current paths between electrodes are not confined to the front surfaces but will be distributed proportionally over the whole of the front and back surfaces and the terminal support, unless these rear surfaces are completely insulated. The proportional distribution of current between front and rear surfaces is not a constant for all electrolytes; it may vary with throwing power of the salt measured.

For these reasons it is preferable to evaluate the cell constant by measuring its actual resistance characteristic with a high purity salt such as potassium chloride, of known specific conductance. The constant is derived by manipulation of equation #1.

Jones and Bradshaw[1] have determined the absolute specific conductance of potassium chloride, and their data, given in Table I, is generally accepted as a working reference.

Table I.
Specific Conductance of Potassium Chloride
(mhos per centimeter)

Demal* Concentration	0°C	18°C	25°C
0.01	0.000774	0.001220	0.001408
0.10	0.007137	0.011166	0.012856
1.00	0.065176	0.097838	0.111342

*A demal solution is one having one gram molecular weight of solute dissolved in 1000 grams of water at 0°C. The term is used in preference to *Molar Concentration* (which has similar dimensions, i.e., 1 gram mol. per liter of solution), to imply high precision of measurement. For example, a salt such as nickel sulphate may contain six molecules of water of crystallization ($NiSO_4 6H_2O$) and would have a molecular weight of 262.84. The molecular weight of $NiSO_4$ is 154.75 and is the value used to define a molar solution. The water of crystallization adds to the solvent water and must be accounted for.

The Parker Effect

The cell constant has been observed by Parker[2] to be a dependent function of the solution measured and may vary with concentration and/or frequency. It is not the purpose of this *application* paper to derive the theoretical arguments underlying the phenomena of

[1]Grinnell Jones and B. C. Bradshaw, J. Am. Chem. Society, vol. 55, p. 1780 (1933)
[2]H. C. Parker, J. Am. Chem. Soc., vol. 45, pp. 1366-2017 (1923)

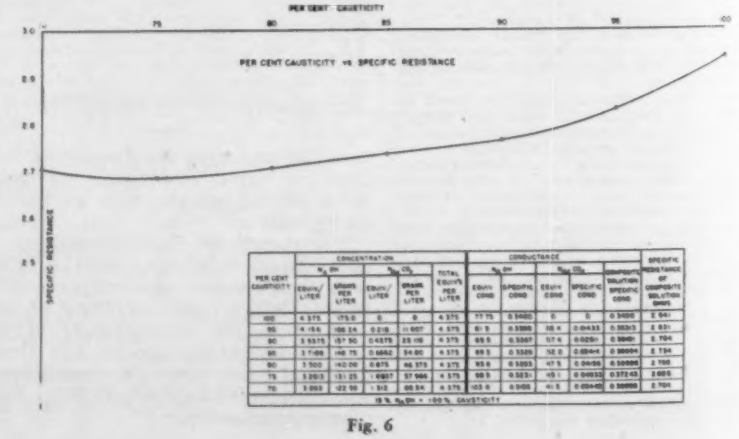

Fig. 6

polarization and the errors introduced by the *Parker effect*. Jones and Bollinger[3] have shown that the Parker effect is a result of distributed capacity in the system—particularly in the cell and its leads. This may be minimized by designing the cell with wide separation of the electrode leads and by using a balanced bridge having equivalent series and parallel capacitance arms. Capacitance in the "cell arm" of the bridge is in series with the resistance component and may be minimized by an equivalent parallel capacitance in the "balancing arm". For high precision measurement it may further be necessary to shield the circuit.

Polarization

To explain the mechanism of polarization, we shall accept the work of Clausius and Mosotti and that of Debye[4]. They have shown that organic and inorganic matter is subjected to dielectric forces of *displacement* and intensity when exposed to an electric field. Substances which exhibit a permanent electric moment are called *polar molecules*. Others are nonpolar in varying degrees, but become polarized temporarily when subjected to an electric field. If the field is of low frequency and the concentration or viscosity high, the molecules cannot orient themselves independently of the fluctuations in the current. However, as the frequency is increased and the viscosity or concentration lowered, the molecules can orient themselves and are less affected by current alternations.

The phenomenon has also been explained on the basis of statistical analysis following the classical Maxwell and Boltzman distribution law, which expresses the number of molecules exhibiting a given moment as a function of the number contained in a given volume increment. The Arrhenius dissociation theory, which applies to dilute solutions, loses its linearity at high concentrations because of reactionary forces between ions which become manifest as polarization. Coulomb's law states that the attraction (f) between two charged bodies at a distance (r) apart in a medium of dielectric constant (D) is:

$$f = \frac{q_1 q_2}{Dr^2} \qquad (3)$$

where q_1 and q_2 are the respective charges on the bodies.

We know that when a potential difference is applied to the electrodes of a cell, the ions accelerate until the applied force of the emf is equally opposed by retarding forces within the solution. The retarding forces vary non-linearly with concentration and thus may result in an increase or decrease of the cell constant depending upon their nature and origin.

Because of the Coulomb forces, it is not possible to obtain uniform distribution of molecules within a solution. A positive or negative ion will tend to be surrounded by more ions of unlike than like sign, but the symmetry of the "ionic atmosphere" is disturbed by the Brownian movement. This asymmetrical distribution affects the velocity of an ion in an electric field; the forces of ionic attraction oppose those of the externally applied field and increase in intensity of effect with concentration. As one ion, say a positive ion, is "freed" from the influence of a "cloud" of negative ions, it increases its velocity until another group of negative ions are formed around it. The time required to regain its initial velocity is termed *relaxation time*.

The relaxation time is a function of the ion mobility (velocity in cm per second); and, since the hydrogen ion has the greatest velocity, we could expect quicker recovery and less polarization in dilute acids than in the same concentration of salts of metals of higher atomic weight. It is also apparent that the relaxation time is affected by concentration since the radius of the ionic atmosphere becomes infinite at zero concentration—hence, zero polarization.

Without a deliberate attempt to aggravate the already complicated picture, it is necessary to introduce another variable, namely *electrophoresis*. Ions in solution tend to "take on" solvent molecules and carry them throughout the course of their journey. This electrophoretic effect, aside from contributing to polarization, tends to retard forward displacement of the solute by virtue of its viscous drag. It is of interest to note in this respect that the viscosity of water decreases by about 2½ percent per degree C at 18°C, and the conductivity of an electrolyte increases by the same amount with the same change in temperature.*

The layman might best visualize the problem of polarization comparatively as the probability of his freedom to run unimpeded in a straight line from one end of a large room to the other when the concentration of other people is low, as compared to his chances of retaining a straight course when the room is crowded with many other people and everybody else is attempting to run in all possible combinations of horizontal directions. It also makes a difference on his viscosity coefficient if he is attempting to carry some electrophoretic "hitch hiker" of his own or greater weight. There is little doubt of his chances of getting through without becoming completely polarized.

Acree and co-workers[5] have made oscillograph studies on electrolytes and conductance cells to determine their behavior under transient voltage conditions and frequency pulses. Their data shows a departure from sinusoidal wave form when the polarization voltage is exceeded, and they have observed that the mechanism of cell behavior is exactly that of a capacitor and resistor in series. The series capacitance effect is explained on the basis of transference numbers of ions, which, being unequal for cation and anion, results in segregation and a nonhomogeneous boundary layer at the electrode interface.

The effect of parallel capacitance or lead shunt capacitance (The Parker effect) at 60 cycles is to cause an angle of current lead of only 0.05 second of arc. This can be ignored for industrial measurements.

However, at this same frequency, the polarization due to ion segregation effects which cause the cell to behave as a series capacitance, is 58° of lead —or approximately equivalent to 7000 microfarads capacitance. It was also observed that at 1000 cps, the angle of lead due to the series capacitance effect is approximately 44,000 times greater than the current lead due to the Parker effect.

Equation #3 above would seem to indicate that reactionary forces between ions decrease with increasing dielectric constant of the solvent. This is known to be the case, and the polarization of conductivity cells has been observed to increase inversely with the dielectric constant of the solvent.

Water has a relatively high dielectric constant (78.6 at 0°C)[6], and its effect on the equivalent conductance[7] with increasing concentration of an electrolyte is to show a decrease with approximate uniformity. However, if we replace the water solvent with a nonaqueous medium such as dioxane, with a dielectric constant of 2.2, we find that, by plotting log equivalent conductance against log concentration, the curve loses uniformity and may pass through alternate minima and maxima. If we make a number of solutions containing progressively increasing ratios of dioxane to water, we find that not only is log λ materially reduced in absolute value, but the effect of increasing concentration is reversed. Whereas an increase of solute concentration in water decreases the equivalent conductance, the same solute concentration in dioxane shows a remarkable increase in log λ and at a very steep average slope (curve not uniform).

The dielectric constant of water decreases with increasing temperature (i. e., 44 at 100°C), and it has been shown[8] that aqueous electrolytes behave similarly to nonaqueous solutions at elevated temperatures. We would expect, therefore, that polarization errors, from this effect for a given concentration, would increase with temperature.

It is further to be noted that the equivalent conductance of aqueous electrolytes decreases, with increasing concentration, at a rate inversely with increasing valency of the solute ions. In other words, a monovalent electrolyte produces less polarization than a multivalent solute at a given molecular

[3]Grinnell Jones and G. M. Bollinger, J. Am. Chem. Soc., vol. 53, p. 411 (1931)

[4]For a full theoretical treatment of the theories of Clausius and Mosotti and of Debye, see "Polar Molecules." P. Debye, Chemical Catalog Co., N. Y. (1929)

*The viscosity coefficient of water is not independent of temperature; it decreases by approximatly 1% at 100°C and 3.5% at 0°C.

[5]S. F. Acree, Edward Bennett, G. H. Gray and Harold Goldberg, "Studies of the Measurement of the electrical conductivity of solutions at different frequencies". Jour. Phys. Chem. Vol. 42, No. 7, pp. 871-894, October 1938.

[6]Our theoretical concepts of dielectric constant do not permit us to assume that a given value is independent of environment and the writer has no record of experimental evidence to indicate that the dielectric constant remains unchanged in solution.

[7]The equivalent conductance (λ) of an electrolyte is defined as the conductance value obtained between two electrodes 1.0 cm apart and large enough in area to contain one equivalent weight of solute. It is expressed by the equation

$$\lambda = \frac{1000}{N} c \qquad (4)$$

where N is the equivalent concentration and c the specific conductance.

[8]C. A. Kraus, "The Properties of Electrically Conducting Systems," Chemical Catalog Company, Inc., N. Y. (1922).

concentration and degree of dissociation. The best way to visualize such phenomena is by means of Maxwell's law of distribution.

The effect of high pressure on the effective cell constant[9] is of unusual interest. The equivalent conductance of strong electrolytes (i.e., high degree of dissociation) passes through a maximum of increasing pressure. The pressure maxima diminish with increasing atomic weight of the solute and also increasing temperature. Fig. 7 is a plot of the equivalent conductance of various strong electrolytes at varying pressures and temperatures and illustrates the effect of these conditions upon the behavior of such molecules. The effect of pressure upon weak electrolytes is to increase their electrical conductance to a greater extent than strong electrolytes. It should also be noted that increasing pressure increases the dielectric constant of water, and this, too, should result in an increase of conductivity of the solute molecule.

The direct current produces a type of polarization known as concentration polarization. Cations migrate to and accumulate at the negative electrode, while anions may accumulate or be discharged at the positive terminal. The electrolyte thus becomes nonhomogeneous and the potential drop across the cell increases rapidly. It is for this reason that dc cannot be used for conductivity measurements except in the extremely high (megohms) resistance ranges.

Impurities on the electrode surfaces, or nonuniform platinizing, will produce rectifier action in the cell; or certain electrolytes such as phosphates and aluminates, which conduct the current irreversibly, behave as electrolytic rectifiers and introduce enormous polarization errors. The platinum black coating may occlude foreign matter, and, for this reason, better results can be obtained in some cases with large bright electrode surfaces (viz., high accuracy determination of the conductivity of distilled conductivity water).

Cell Characteristics

The effect of capacitance and polarization on the characteristics of some conventional types of cells is illustrated in Figs. 8 and 9. These data also illustrate the Parker effect and express the cell errors in terms of operating frequency and measured resistance. It is interesting to note that capacitance effects increase with operating frequency while resistance errors become more pronounced at the lower measured values. It may also be noted that concentration anomalies exist in certain of these cell characteristics, which may possibly be the result of rectifier action of the electrolyte. Polarization errors become more pronounced at lower frequencies and higher concentrations; but, in general, with certain types of cells a precision of 1.0% is not difficult providing the frequency is 300 cps or higher. It is of particular interest to note that conductivity data become more valid with these cells

[9]The *effective* cell constant implies that an effective change in calibration may result if the cell is standardized at low pressure and used at high pressures, widely different.—The instrument engineer may see in Fig. 7 a method to measure pressure from 15,000 to 150,000 psi.

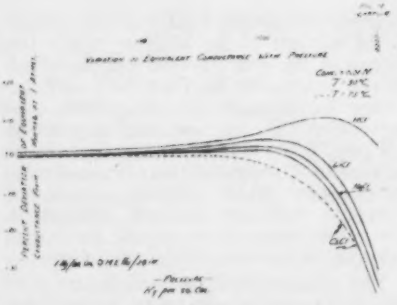

Fig. 7

at lower concentrations below 0.1 Demal.

Although the cell characteristic tends to become stabilized at high values of measured resistance, a limit in precision is approached because of the effect of water on the total measured conductance. A 0.0001 Demal solution of K Cl has a specific conductance of approximately 13×10^{-6} mhos, whereas the conductivity of distilled water is 1×10^{-6} mhos - cm^{-1}. The conductivity due to water is more than 13% of the total. Increasing the concentration of solute reduces this error so that with a 0.01 Demal solution the error is negligible. For absolute measurement the conductivity of water must be subtracted from the total to obtain the true conductivity of the solute.

Fig. 10 is a plot of variations in cell constant at various frequencies of a low-capacitance "precision type" cell designed by Jones[3] to minimize the Parker effect. It is manufactured in different sizes with constants of 0.05 and greater. Polarization errors are prohibitive with this cell at low power

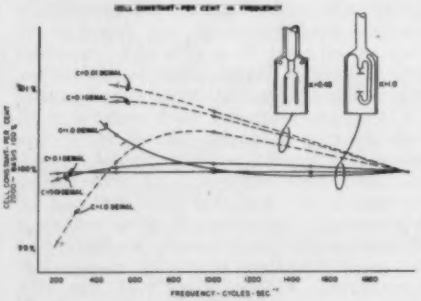

Fig. 8

frequencies and low values of measured resistance, and, therefore, it has little practical value for industrial plant applications. It is only applicable for precise measurements at high frequencies and low concentrations where cell inter-electrode capacitance must be kept to a minimum.

The similarity of Figs. 11 and 10 is striking, but the Parker effect is more pronounced in this cell than in the Jones precision type. The electrode leads run parallel and are not widely separated as in the Jones cell and its characteristic curve is not so uniform. It should be noted that the error is a greater function of concentration in the lower frequency ranges but becomes stabilized at a value of approximately 200 ohms at 60 cps or 100 ohms at 1000 cps. It should be further noted that increasing the frequency above 1000 cps offers little practical gain commensurate with circuit difficulties which would be introduced by capacitance effects at these frequencies.

The Parker effect and polarization errors limit the practicable resistance range of cells to a minimum of 500 ohms and a maximum of 50,000 ohms measured resistance for precision measurements. Polarization establishes the lower limit while the alternating current errors increase approximately as the square of the measured resistance.

Industrial applications do not require high absolute accuracy and these limits may be extended to a maximum of 100,000~ and a minimum of 50~ for accuracies of 1.0% to 5.0%, providing stability and reproducibility are not sacrificed.

It is apparent, however, that electrolytes have widely varying values of specific conductance, and, to minimize cell errors, a cell must be selected with an appropriate constant to limit the measured resistance within a specified range.

Cell Design

The major limitation of the foregoing cells for industrial application is their glass construction and mode of application. They are principally "dip type" cells and are applied by "over the top" suspension in open tanks or troughs. Breakage is high and the mortality rate, occasioned by operator handling, renders the design unattractive for industrial usage. The application of these cells to industrial instrumentation has been patterned after laboratory techniques and little progress has been made in design to meet preferred industrial techniques.

In a recent study of cell design for certain industrial applications, the writer made tests on a unit similar to Fig. 12 for pipe-line insertion. This cell was constructed of plastic material and fitted with flanges for easy insertion in a pipe-line section. It was provided with block and by-pass valves similar to practices used in control valve installations.

The practicability of such a cell is immediately evident, but it is subject to "shunt path" errors caused by currents passing through the piping and processing equipment which shunt the current paths between the electrodes of the cell. In other words, the cell constant is not a simple function of electrode area and spacing. It is affected by the shunt path through the piping and equipment.

These errors may be minimized by the use of a three-electrode cell in which the central electrode serves as a "guard electrode." The three electrodes may be connected in various combinations of pairs to a two-lead circuit, and each combination has a characteristic bearing on the linearity and constant of the cell. This effect of changing combinations is not marked at the higher values of measured resistance, but the symmetrical arrangement illustrated in Fig. 13 gave the highest order of stability for any given measurement. It also decreases the effective cell constant. This cell, like the foregoing, is affected by concentration polarization in the low resistance ranges, but its constant was observed to drift only 10% at 50 ohms measured resistance from the reference value at 2000 ohms.

Another cell which has been used satisfactorily in industrial work is the

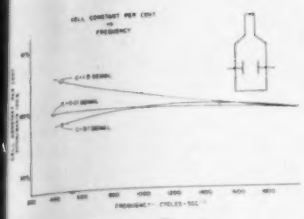

Fig. 9

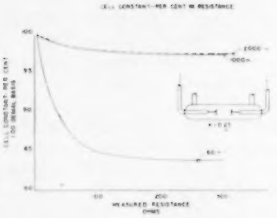

Fig. 10

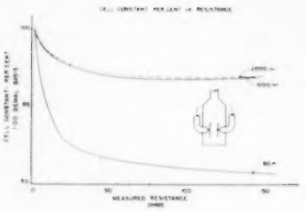

Fig. 11

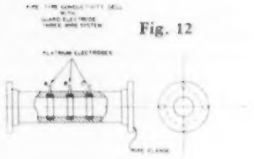

Fig. 12

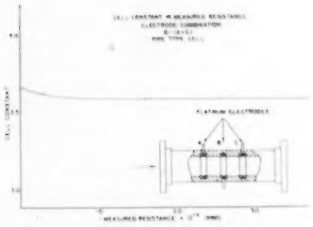

Fig. 13

outboard type illustrated in Fig. 14. This cell is connected in a by-pass line taken from the main process flow line, and its overflow returned to some point of lower head in the system. The cell constant is adjusted by sliding electrodes "A" up or down in the shield skirts "B". The guard electrode "C" is usually made stationary but can be adjusted to effect a change in cell constant. The principal advantage of this cell is its mechanical ruggedness and freedom from breakage occasioned by operational hazards. It can be serviced readily or replaced in short time without disturbing the process piping.

It cannot be emphasized too strongly that the principal merit of the outboard and pipe-line cells, and their outstanding advantage over commercial dip type cells, is their relative freedom from polarization errors. The test solution moves rapidly past the electrodes and minimizes the tendency for polarized ions to accumulate, as is likely to be the case with dip type cells mounted in open tanks or troughs.

The temperature coefficient of resistance varies with the electrolyte measured similarly as with metallic conductors with the exception that it is usually a negative coefficient. Empirically, it varies approximately 2½% for each 1°C change in temperature.

This imposes a serious limitation upon design of equipment for universal application, and necessitates that compensation circuits be designed for each application or that approximate compensation be used. It is customary practice to use the latter method in most commercial equipments wherein a variable resistance compensates for temperature at the operating value but is valid only over a limited concentration range.

A very satisfactory solution to this problem has made its appearance in the technique of comparison measurements using a Bishop type cell illustrated in Fig. 15. This method is particularly applicable when it is desired to hold measured resistance at some fixed value and to compensate for temperature variations over relatively wide limits.

The Bishop method consists of one standard cell with fixed constant and a measuring cell having a variable constant. The standard cell is filled with a reference solution which it is desired to duplicate in the process and is placed in the processing vessel alongside the measuring cell. The two cells are connected in opposing arms of a 1 to 1 ratio bridge and the constant adjusted to give coincidence with the standard at any practicable value required within limits. Temperature variations affect both cells to the same extent and thus compensate directly. The accuracy of this method, as in all comparison measurements, is high since deviations are from zero reference base.

Some progress has been made with pressure cells. Standard types are available for pipe-line insertion or applications to the mud drum of boilers, where pressures do not exceed 150 to 250 psi at temperatures below 200°F. They are inserted through gate valves which permit ready removal for service without disturbing the processing unit.

Spark plug type cells have been used satisfactorily on autoclaves and digesters operating at pressures of 250 to 500 psi. In general, the field of high pressure conductivity equipment has not been fully explored. Equipment must be especially developed to meet specific needs.

The Bridge

Although conductivity measurements are made using alternating currents and the bulk of industrial equipment operate at power frequency, true conductivity data are based on the dc resistance characteristic of a solution. Fortunately, with proper cell and instrument design, measurements are made at near unity power factor and the ac resistance approaches the true dc value. The low-voltage ac bridge circuit constitutes the majority of equipment for industrial application, although it is quite common practice to use dc bridges or VT voltmeters in the megohm resistance ranges where polarization errors are nil because of the small magnitude of currents passed. Stability of measurement is preferred in this range in lieu of accuracy, which may vary from 5% to 20%.

It has been pointed out above that the cell is the limiting factor in accuracy of industrial conductivity measurements. Although the total cell resistance should be limited to a minimum of 100-50 ohms for accuracies of 1 to 5% over a practicable turn-down range, the bridge is capable of lower resistance measurements with the same or greater accuracy. It is not uncommon practice, therefore, with some commercial equipment to operate at much lower resistances and to limit the turn-down range to obtain a practicable measurement, with acceptable reproducibility, even though the cell may be operating in a range of high polarization and low accuracy.

It is customary practice to limit the bridge to a lower limit of 10 ohms measured resistance and not to exceed a turn-down range of 10 to 1 and preferably 5 to 1 to maintain bridge accuracies within 1%. It is apparent that if this accuracy is to be maintained, a precision of measurement of 0.1 ohm is required for the lower value of 10 ohms measured resistance. This is about the best that can be expected of low-resistance industrial instruments.

The upper resistance limit is established by instrument sensitivity and the losses which increase as the square of the measured resistance. This limit is approximately 100,000 ohms measured resistance for the above specified accuracy and turn-down.

Special recorders have been built having 1 megohm upper resistance limit with somewhat lower accuracies. Others have been designed with special ranges and wide turn-down, i. e., 5000 ohms to infinity, but are used as leak detectors and do not require comparable accuracy over the full range.

Vacuum tube voltmeters have extended the upper useful range of bridges with practicable accuracy to several megohms measured resistance.

Cell constants may be adjusted for a given application to maintain measured resistance within optimum limits. These constants may vary in commercially available units from 0.1 or less for high resistance electrolytes to 100 or above for solutions of low resistance.

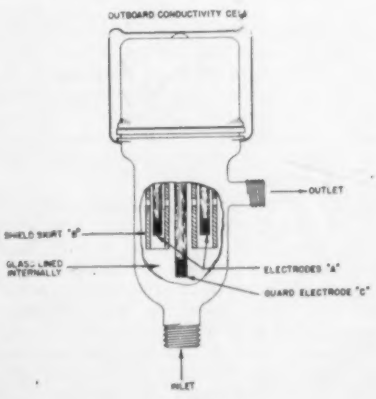

Fig. 14

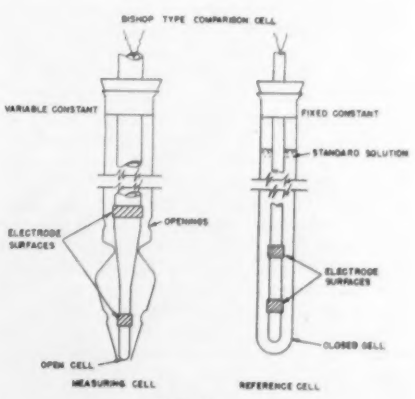

Fig. 15

The majority of industrial conductivity measurements are made on grounded solutions. It is necessary, therefore, to eliminate direct or leakage grounds in the bridge circuit and to minimize capacitive or magnetic coupling of the circuit components and leads to eliminate feedback errors. An empirical rule to follow on this is that the capacitive coupling between two wires varies approximately inversely as the square of their distance apart. Shielding may be required in bridges for high precision work, but is not necessarily required for industrial instruments operating at power frequencies with an accuracy of 1.0%.

It must be remembered that the relationship desired in a conductivity bridge is

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \qquad (5)$$

but this can only be true if the reactances of all arms are equivalent and

$$\frac{X_1}{R_1} = \frac{X_2}{R_2} \qquad (6)$$

likewise

$$\frac{X_3}{R_3} = \frac{X_4}{R_4} \qquad (7)$$

The important advantage of operating industrial equipment at power frequencies is that reactance errors are negligible at the accuracies required and the necessity for special precautions is minimized. High precision bridges are subject to reactance errors, and precautions must be taken to balance out and "ground" the capacitive components.

The paradox of conductivity measurements is that to obtain precise data one must be guided by the solution characteristics and cell behavior which requires operation at high frequencies and within definite resistance limits where the limitations are introduced by the bridge. To obtain continuous industrial measurements with simplified equipment operating on grounded solutions, one is limited by the availability of commercial equipment and must be guided by instrument characteristics which require operation at low frequencies, where the limitations are introduced by the cell and electrolyte behavior.

At 60 to 250 cycles, the effect of capacitance coupling between lead wires is not so pronounced as at 1000 cps or above. Industrial installations at 60 cycles have been made with cell leads of 50 feet and above and have operated satisfactorily over a wide range of measured resistance from 50 ohms to several hundred ohms. The same length of lead wires on 1000-cycle bridges was found to produce a slightly greater shift in effective cell constant over the same range of measured resistance.

Although the parallel capacitance or Parker effect is more pronounced at higher frequencies, the series capacitance and ion segregation effects are reduced at these frequencies. In any event, whether operation be at 60 or 1000 cps, the important criterion of a good industrial installation of conductance instrumentation is not its absolute accuracy but rather its stability and reproducibility. These instruments must, in all cases, be standardized by standard analytical procedures, particularly under conditions of operation at the desired value of measured resistance, and it is more important that they retain this calibration over a practicable operating period. The higher frequencies of 1000 cps favor greater stability in the low ranges of measured resistance, but the comparative advantages of stability of industrial measurements at this frequency in the higher resistance ranges are not pronounced.

Constant Current Conductance Measurements

It would seem, from the foregoing discussions on polarization, that conductance measurements at constant current would offer many advantages for industrial instrumentation, particularly if the current were set at a low value to avoid high resistance heating effects and low resistance polarization. Many electronic instruments have been developed, employing this principle; and, although they have found their greatest field of application as conductance limit indicators and/or controllers, they have proved to be reliable industrial instruments for specific applications. In some cases, in the writer's experience, they have shown greater stability of cell calibration in the low resistance ranges than 60-cycle recorders operating on the same solution.

Conductance measurements at constant current are, in many cases, particularly well adapted to industrial instrumentation. The low currents require sensitive and stable detectors which are capable of controlling a feedback voltage or current to maintain the cell current constant over its practicable range of resistance. To obtain this feedback coupling with any practical degree of linearity over a useful turn-down range requires operation at relatively high frequencies of a kilocycle and above. Stability of cell calibration is favored by both conditions of high frequency and low current, but the application of these devices as wide-range industrial recorders has been impeded because of the relatively narrow turn-down range over which they produce linear feedback. Fig. 16 illustrates the principle of feedback voltage control to obtain constant cell current.

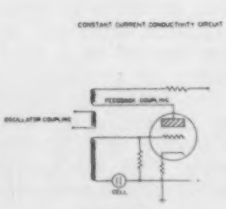

Fig. 16

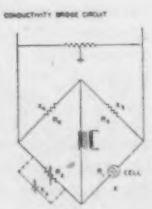

Fig. 17

The Wheatstone bridge is essentially a constant potential device. When connected and operated as indicated in Fig. 17, it maintains constant potential drop across the cell at balance. It has found more widespread industrial usage as a wide-range recorder than the constant current devices.

If the potential drop across the cell is large and the concentration gradient at the electrode interface is not uniform, there is danger of introducing phase shift errors. It was shown some time ago that there is an optimum potential for a given electrolyte. If this potential is not exceeded, the equivalent series capacitance at 60 and 240 cycles is independent of current and applied voltage. Acree[5] found that by increasing the electrode potential from 0.56 to 6.9 volts, the series capacitance increased from 8200 to 76,700 microfarads.

Phase shift errors have been found to be bothersome in some high-voltage relays which were designed as limit alarms, although converted to operate as indicators over a limited range. In general, these errors have occurred as a result of improper application of the equipment. Conductance type liquid level alarms and salinity limit relays have their place as high-voltage instruments, and they should not be converted for wide-range concentration measurements.

One cannot overemphasize the importance of selecting the proper method and type of instrument to measure and regulate concentration. It can be said in a broad sense that it is the most important variable in all processing; In fact, it may further be said in a broad sense that the only purpose of chemical processing is to bring about a change in the concentration variable. Kinetics tells us that the fundamental variables which effect a chemical reaction are (1) pressure, (2) temperature, (3) concentration, and (4) time. All these variables enter into the instrumentation problem, but the only direct measurement of results is concentration.

Time is a linear independent measurement and behaves the same regardless of application. Temperature and pressure are likewise independent quantities and problems of application do not differ with processes except for mechanical details. On the other hand, concentration is materially dependent upon the application. Each problem must be fully appraised to determine the best method and proper instrument to use. One must consider (1) What is it that we wish to measure the concentration of—and within what range and accuracy? (2) What are the interferences that will limit the usefulness of a given method? (3) Which method of measurement will best meet the requirements?—etc. One will find that each and every concentration problem requires individual analysis and a good instrument engineer will not attempt to use a liquid level or limit relay as a calibrated instrument for measurements.

Limitations

Conductivity is limited as to its reliability as a control quantity, depending upon the application and the characteristics of the solution measured. For example it, cannot be used independently with reliability to regulate oleum strength or concentration of strong sulphuric acid, unless supplemented by frequent laboratory assay analyses of the regulated material. There are two principal reasons for this limitation. First, the cell is operating in a region of very high molecular concentration and strong polarization and does not retain absolute calibration over any but a very narrow turn-down range. Secondly, the resistance characteristics of strong acid pass alternately through maxima and minima; and, should a large load swing be encountered, there is danger of "overriding the hump".

Conductivity can be used safely as a control quantity when applied to media

hich exhibit a broad range of uni-rm resistance characteristics, and e concentration is not within a range hich introduces excessive polarization d limited turn-down. The control aracteristic, in most cases, is non-near, and the extent of nonlinearity entirely a function of the ionization aracteristics of the material meas-red. Strong acids such as HCl and ectrolytes having high dissociation nstants approach linearity and ex-bit a sufficiently broad range to be nsidered linear for purposes of in-strial control. The instrument scale ay be calibrated in total ion concen-ation, in which case it will have uni-rm divisions; or it may be calibrated nuniformly in total molecular con-ntration—but in either case, the con-oller usually follows a nonlinear con-ol characteristic.

Conductivity instruments cannot be assified as absolute assay concentra-on devices because of the concentra-on anomalies involved. They are best plied as operations guide instru-ents, whereby they are standardized the one value of indicated concen-ation desired in the process and are ed only to provide a continuous rec-d of operating conditions. They must, any case, be supplemented by labora-y assay analyses to check calibra-on.

The major limitation of all conduc-ity equipment from an industrial erations point of view is the main-nance requirements of electrode sur-ces. They require frequent platiniz-g to eliminate "poisoning errors", d it is not advisable to expose the rface to abrasive materials or sludges suspensions (especially in the low sistance ranges) which will erode way the surface coating. The plati-m black coating is vulnerable to at-ck by foreign matter, which reduces effective surface area and sets up calized potential areas at the point contact. Certain sulphides and selen-es are particularly bad in this re-ect. Polarization errors also make e equipment unattractive, in many ses, for measurements of high con-ntration.

This problem has been approached th a type of equipment which re-onds to variations in circuit "Q" ought about by changes in effective sistance of the test solution which ws through an insulating tubing ving electrodes attached to the outer rfaces. The electrodes do not contact

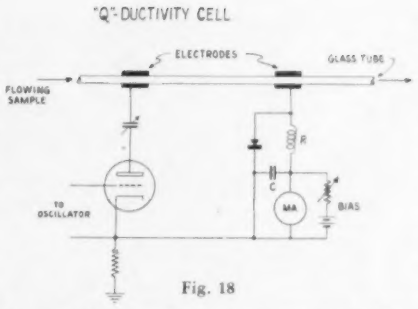

Fig. 18

the solution and do not require special treatment other than maintenance of clean bright surfaces at the point of contact with the glass tube.

The circuit illustrated in Fig. 18 consists of an oscillator capacitively coupled to the electrodes of the test cell and thence to a recording microammeter through a filter and rectifier network. Variations in resistance of the solution to rf currents affect the circuit "Q" and result in a change in plate current. This equipment operates at a megacycle frequency and has been used successfully in automatic control to maintain solution concentration to within 1 part in 60,000, and it is claimed that it is especially applicable to solutions of relatively high concentration.[10] "Q-metric" titrations (Fig. 19) bear striking resemblance to the classical conductance titration shown in Fig. 20.

Further work has been reported on the use of magnetic properties of electrolytes as a means of evaluating concentration. Like conductivity methods, these devices require specific calibration, but they remove the objectionable feature of electrode maintenance and minimize the problem of errors at high measured concentrations. Conductivity methods, in general, have provided for the process control engineer a valuable tool for the measurement of the concentration variable. Equipment design, however, has not advanced sufficiently to alleviate the application problems of breakage and maintenance, and there would appear to be adequate justification for further work in keeping with application requirements.

The foregoing discussions pertain largely to conventional low frequency techniques (60 to 1000 cps) at relatively low potential gradients, where ion velocities are of the order of 0.001 centimeter per second. There is experimental and theoretical evidence to indicate that many advantages lay in the region beyond; at frequencies where the period of oscillations is well below the ionic relaxation time, the ion atmosphere is not distorted and a conducting ion behaves as though it were standing still and does not introduce the effects of polarization of one in motion. In the region of very high voltage gradients, where the ion velocity may become several hundred millimeters per second, the effects of electrophoresis are absent and ion clouds

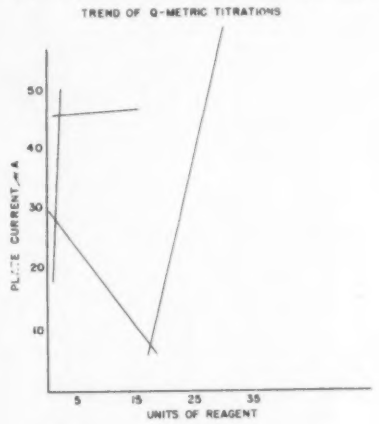

Fig. 19

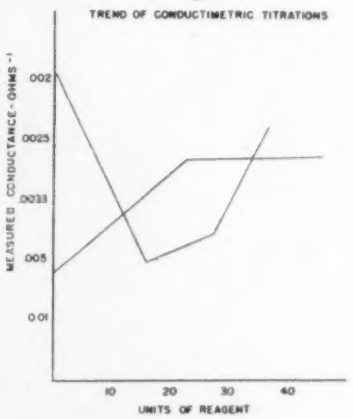

Fig. 20

do not form. The conductance behavior of an electrolyte approaches its theoretical behavior at infinite dilution, and many anomalies of concentration disappear.

[10] G. G. Blake, Journal of Scientific Instruments, 24, pp. 101-102 (April 1947); 22 pp. 174-176 (1945).

Section News

(Continued from page 272)

oneywell Regulator Company and the own Instrument Company Division.

—W. J. Claffie., *Corr.*

KANSAS CITY

The Kansas City Section met on January th at the Crossroads Restaurant. During e short business meeting following din-r Mr. Oliver L. Boutros, of Boutros In-rument Laboratory, was re-elected nation-delegate (Director) for 1948.

The speaker of the evening was Mr. W. Wheeler, of Askania Regulator Com-ny, Chicago, Illinois, who presented an ustrated lecture on "Automatic Controls d Their Applications for Proportioning of uids." Most of the members learned for first time how proportioning control s obtained through the jet pipe regula-r. Mr. Wheeler was a very enlightening d entertaining speaker, and all present joyed the talk immensely.

—W. A. Reichow, *Corr.*

LOUISVILLE

The January meeting of the Louisville ction was held in the Seagram Auditorium on Tuesday, January 27th. Mr. Robert C. Thomas and Mr. Paul B. Smith, both of Joseph E. Seagram & Sons, Inc., presented the program.

Mr. Thomas, Mr. Smith and Mr. E. H. C. Brown, Director of Instrumentation at Seagram's had been greatly impressed by a certain automatic control lecture and demonstration presented at the Second National Instrument Conference and Exhibit in Chicago in September, and this program was an attempt to duplicate in some measure the Conference demonstration.

As Mr. Brown stated in introducing the program, "Any resemblance between this program and the one presented by the Eastman Kodak Company (Akins and Kowalski) in Chicago is purely complimental."

The evolution of control from on-off to the anticipatory action of derivative response was explained by Mr. Smith and demonstrated by Mr. Thomas on a model built by Mr. James J. Hand, also of Seagram's. This is one of the few programs which has been given by local talent, and its success caused all of us to see the possibilities of interesting programs conducted by our own membership.

At a previous meeting the following officers were elected for 1948:

President—Joseph J. Monahon Jr., E. I. duPont deNemours & Co., Inc.

Vice-President—Joseph E. Ballard, Joseph E. Seagram & Sons, Inc.,

Treasurer—Melvin J. Johnson, B. F. Goodrich Chemical Co.

Secretary—Paul B. Smith, Joseph E. Seagram & Sons, Inc.

—Paul B. Smith, *Sec'y*

NEW YORK

The January meeting of the New York Section was engulfed in the New York Regional Conference held at the Hotel Pennsylvania January 30 and 31. Sponsored by the New York Section, the Conference was a success (as reported elsewhere in this issue) and we hope to sponsor a similar meeting next year on the general subject of "Pressure Elements."

A short business meeting of the Section, held on the 30th of January, resulted in the election of the following officers for the year 1948:

President and Director—Ralph R. Batcher, Electronic Industries.

Vice-President—E. R. Manning, Weston Electrical Instrument Company.

Treasurer—Norman J. Cherry, The Bristol Company.

Secretary and Correspondent—Charles E. Haggerty, Department of Public Works, City of New York. (Home address: 7552 181st St., Flushing, L. I., N. Y.)

—CHAS. E. HAGGERTY, *Sec'y.*

NIAGARA FRONTIER

The Niagara Frontier Section held its monthly meeting on January 26 at 8:00 p.m. at the New York State Institute of Applied Arts and Sciences in Buffalo.

A short business session, directed by President Clarence Boltz, was held and reports were received from the Treasurer and from the Publicity, Program and Educational committees. An interesting discussion centered around the instrumentation course planned to start in Buffalo in September, and the course now being conducted in Niagara Falls under the direction of Educational Chairman Joseph Serpa.

The main event of the evening was a presentation by Dr. A. H. Croup entitled "The Romance of Paper Manufacturing." Dr. Croup, Director of the Research Laboratory of Hammermill Paper Company, Erie, Penna., and President of the Presque Isle Section of the I.S.A. accompanied his talk with a motion picture, in color, depicting the operational sequence in the manufacture of paper.

Dr. Croup stressed the importance of maintaining accurate temperatures and pressures in the digesters, each of which processes 40 tons of chips at one time. Temperature and pressure in the digesters are gradually increased automatically through pilots using a cam arrangement. The speaker indicated a need for more accurate continuous indication of moisture content in the wood chips as they are fed to the digester; also continuous measurement of paper thickness, weight and consistency.

An interesting discussion followed this presentation, and Dr. Croup offered data on the tremendous quantities of raw materials used in the paper industry, an indication of the confidence reposed in the instruments controlling the processing of material of great value.

Mr. Russell Milham, formerly Correspondent and Publicity Committee Chairman of the Niagara Frontier Section has become associated with the Foxboro Company, Foxboro, Mass., effective February 1, 1948. Members of the Niagara Frontier Section view his departure with regret, but wish him success and good fortune in his new venture. —W. J. SOMMERS, *Corr.*

NORTHERN INDIANA

The January meeting of the Northern Indiana Section was unique in that it was a "get back to fundamentals" meeting. Mr. J. H. Flannery, instructor at Purdue Extension University, addressed the group on the fundamentals of physics. He showed how all forms of work can be divided into several classifications — the screw, the inclined plane, the lever, the wheel and axle, the pulley, etc. He also presented several experiments to illustrate the laws of Boyle, Charles and Gay-Lussac. The talk dwelt with fundamentals which we all know, but was particularly interesting because it gave many of us a chance to brush up on, and get a little different slant on the things which are the basic principles used in our work.

On January 31st the Northern Indiana Section sponsored a field trip through the Rosenwald Museum of Science and Industry in Chicago. It consisted of a two-hour conducted tour by one of the University of Chicago assistants, followed by a one-hour demonstration of Radar. Later in the year a tour is planned through the Standard Oil "Cat Cracker."

The February meeting was highlighted by a talk by Bob Larson, Wheelco Instrument Company, who was one of the original founders of the Northern Indiana Section in 1943. Bob demonstrated the new Wheelco Electronic Scriber and the Flamotrol and described their development and operational principles.

Our March meeting will be held on the 18th in the Lake Hotel and will be a round table discussion on Pyrometers. It will be led by men from the Brown Instrument Company. —J. BAUM BECKMAN, *Corr.*

OAK RIDGE

The Oak Ridge Section held its 22nd meeting on February 4th at Grove Recreation Hall. Following the seven o'clock dinner, the meeting was brought to order by President B. B. Bell. Announcement was made of the Smoker to be held on February 20th, at which refreshments, door prizes and entertainment would be the order of the evening.

Ken Burmaster of the publicity committee reported that henceforth the new Oak Ridge radio station, WATO, would carry spot announcements plugging the monthly meetings of the Section — and free of charge! The drawing for a door prize (a new innovation) was held, the prize being an I.S.A. lapel pin.

At the conclusion of the business session, the meeting was turned over to "Tiny" Isenhour, Section Director, who introduced the illustrious speaker of the evening, Mr. J. B. McMahon, Application Engineer, Republic Flow Meters Company, Chairman of the Sections Committee of the I.S.A., member of the Executive Committee, and above all, a swell fellow. By special request, Mac gave a brief resume of the recent New York Conference, and reported on the national affairs of the Society in general. Then into his now famous "Experiences of an I.S.A. Man Aboard."

The entire talk was more or less in the form of a travelogue—impressions of the English people, their manufacturing problems, instrument technology, caste system, rationing, shortages — all adding up to a most educational and enjoyable talk. Color slides taken by Mac's own camera concluded the evening. Infringing perhaps on Mac's pet phrase—it was "first rate."

—J. O. ALEXANDER, *Sec'y.*

PHILADELPHIA

The Philadelphia Section held its February meeting on the 17th of the month at the Penn-Sheraton Hotel. The meeting proved to be one of the most successful of the year with approximately 300 persons present.

President Garner C. Parr called the meeting to order at 8 o'clock, and after a few words of welcome to new members and some announcements of Section activities, introduced Mr. Richard C. Pond, Application Engineer, Taylor Instrument Companies, who presented his demonstration-lecture on "Basic Control Problems."

The use of enlarged charts and an actually operating king-size recorder and complete control system enabled Mr. Pond to trace the fundamentals of control systems from the more elementary "on-off" action to the derivative control functions involved in the more complex systems. Both Mr. Pond and the Taylor Instrument Companies are to be commended on the time and effort put forth in the preparation of the talk and the building of the equipment for the working demonstration.

—JOHN C. KOCH, *Corr.*

ST. LOUIS

The regular meeting of the St. Louis Section was held at the Engineers Club on Wednesday, February 4, 1948. Due to a change in arrangements, meetings for the balance of this year will be held on Wednesday instead of on the first Tuesday of each month as originally planned.

The speaker of the evening was Mr. George W. Baughman, Chief Engineer of the Union Switch and Signal Construction Company, who spoke on "Instrument Applications in Railroad Signaling." Mr. Baughman explained the basic "track circuit" on which the signaling system is founded, and went on to develop the principles of more elaborate systems which have been developed to eliminate line wires. Included in his discussion were the centralized control system, radio control, automatic train control, and other aspects of railroad signal and control work. The tie-up of railroad signaling with instrumentation was clearly shown, and the talk illustrated with excellent slides.

Attendance at the meeting was approximately 60 members and guests.

Previous meetings of the St. Louis Section, heretofore not written up in the JOURNAL, were the December 2nd meeting at which Dr. Ralph H. Munch of Monsanto Chemical Co. spoke on "The Applications of Spectroscopy in Industry," and the January 7th meeting which featured Dr. Willard N. Greer of Leeds & Northrup Company, speaking on "Industrial Electro-Chemical Measurement and Control."

The appointment of Mr. Phil R. Watson as St. Louis Chairman of the 1949 National Instrument Conference and Exhibit, to be held in St. Louis, has been announced by Chairman Forcade. —H. E. ZEFFREN, *Corr.*

WASHINGTON

The meeting of January 19th would have been well worth the while of anyone who missed "Multi-Gun and Special Purpose Cathode Ray Tubes" as presented by Mr. Henry S. Bamford at that meeting. Mr. Bamford is vice president of the Electronic Tube Corporation in Philadelphia. His talk concerned itself chiefly with the design of cathode ray tubes of the (1) multi-gun type having as many as ten electron guns, (2) radial deflection type, (3) polar coordinate type, and (4) potentiometer type. Mention was made of the applications for these tubes in the fields of medicine, internal combustion engine design, seismography, etc., where it is necessary to know the relationship of two or more functions.

Copies of Mr. Bamford's paper may be obtained by writing him.

Mr. W. A. Wildhack, the Washington Section's new President, initiated a new time and a regular schedule for Executive Council meetings. The Council will henceforth meet during the hour preceding the dinner at which the speaker of the evening is the guest of honor.—R. E. HADADY, *Corr.*

WAYNE COUNTY

The February 16th meeting of the Wayne County Section was held in the new location—St. John's Evangelical Church Hall. The door prize, a text book on flow meters donated by Mr. Auraz of Minneapolis-Honeywell Regulator Company, was won by B. K. Beecher. The business portion of the meeting concerned itself to a great extent with the University of Michigan training course in Instrumentation now in session at the Rackham Building in Detroit.

The paper presented by Mr. Hart Fisher of the Monsanto Engineering Department was broad and far-reaching. It included explanations of the instrument man's place in the social and economic structure, his qualifications, training, occupational hazards, his workshop with special tools and equipment, records of work on instruments, his responsibility in the choice and care of new and unusual installations, and his opportunity for advancement. Mr. Fisher also showed slides of special apparatus made and used at Oak Ridge for detection of harmful radiations.

The March meeting, to be held on the 15th, will feature Mr. Alexander Thackara of the Mason-Neilan Engineering Department who will speak on "Ball Float and Displacement Type Liquid Level Regulators." —JOHN MACPHERSON, *Corr.*

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* * *

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